Water Demand Management: Interventions to Reduce Household Water Use

Kelly Fielding[1,2], Anneliese Spinks[2], Sally Russell[3], Aditi Mankad[2], Rod McCrae[2] and John Gardner[2]

November 2012

Urban Water Security Research Alliance
Technical Report No. 94

Queensland Government
National Research FLAGSHIPS Water for a Healthy Country
CSIRO
Griffith UNIVERSITY
THE UNIVERSITY OF QUEENSLAND AUSTRALIA

Urban Water Security Research Alliance Technical Report ISSN 1836-5566 (Online)
Urban Water Security Research Alliance Technical Report ISSN 1836-5558 (Print)

The Urban Water Security Research Alliance (UWSRA) is a $50 million partnership over five years between the Queensland Government, CSIRO's Water for a Healthy Country Flagship, Griffith University and The University of Queensland. The Alliance has been formed to address South East Queensland's emerging urban water issues with a focus on water security and recycling. The program will bring new research capacity to South East Queensland tailored to tackling existing and anticipated future issues to inform the implementation of the Water Strategy.

For more information about the:

UWSRA - visit http://www.urbanwateralliance.org.au/
Queensland Government - visit http://www.qld.gov.au/
Water for a Healthy Country Flagship - visit www.csiro.au/org/HealthyCountry.html
The University of Queensland - visit http://www.uq.edu.au/
Griffith University - visit http://www.griffith.edu.au/

Enquiries should be addressed to:

The Urban Water Security Research Alliance
PO Box 15087
CITY EAST QLD 4002

Ph: 07-3247 3005
Email: Sharon.Wakem@qwc.qld.gov.au

Project Leader – John Gardner
CSIRO Ecosystem Sciences
Qld Bioscience Precinct, Boggo Road
DUTTON PARK QLD 4102
Ph: 07-3833 5552
Email: John.Gardner@csiro.au

Authors: 1 –University of Queensland; 2 – CSIRO; 3 – Griffith University

Fielding, K., Spinks, A., Russell, S., Mankad, A., McCrea, R., Gardner, J. (2012). *Water Demand Management: Interventions to Reduce Household Water Use*. Urban Water Security Research Alliance Technical Report No. 94.

Copyright

Disclaimer

Cover Photograph:

Postcard #2 from the study described in this report. CSIRO (2010).

ACKNOWLEDGEMENTS

This research was undertaken as part of the South East Queensland Urban Water Security Research Alliance, a scientific collaboration between the Queensland Government, CSIRO, The University of Queensland and Griffith University.

Particular thanks go to our talented graphic designer Josh Darrah, The South East Queensland Residential End Use Study Team from Griffith University, the staff at Direct Service Marketing, Tommi Productions, Spot Productions, Pacific Transcription Solutions, and most importantly to the participants who took part in the research.

FOREWORD

Water is fundamental to our quality of life, to economic growth and to the environment. With its booming economy and growing population, Australia's South East Queensland (SEQ) region faces increasing pressure on its water resources. These pressures are compounded by the impact of climate variability and accelerating climate change.

The Urban Water Security Research Alliance, through targeted, multidisciplinary research initiatives, has been formed to address the region's emerging urban water issues.

As the largest regionally focused urban water research program in Australia, the Alliance is focused on water security and recycling, but will align research where appropriate with other water research programs such as those of other SEQ water agencies, CSIRO's Water for a Healthy Country National Research Flagship, Water Quality Research Australia, eWater CRC and the Water Services Association of Australia (WSAA).

The Alliance is a partnership between the Queensland Government, CSIRO's Water for a Healthy Country National Research Flagship, The University of Queensland and Griffith University. It brings new research capacity to SEQ, tailored to tackling existing and anticipated future risks, assumptions and uncertainties facing water supply strategy. It is a $50 million partnership over five years.

Alliance research is examining fundamental issues necessary to deliver the region's water needs, including:

- ensuring the reliability and safety of recycled water systems.
- advising on infrastructure and technology for the recycling of wastewater and stormwater.
- building scientific knowledge into the management of health and safety risks in the water supply system.
- increasing community confidence in the future of water supply.

This report is part of a series summarising the output from the Urban Water Security Research Alliance. All reports and additional information about the Alliance can be found at http://www.urbanwateralliance.org.au/about.html.

Chris Davis
Chair, Urban Water Security Research Alliance

CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

This paper reports on a study of household water use, which trialled three different interventions designed to reduce consumption. Two hundred and twenty-one households in South East Queensland (SEQ) were divided into four groups - three different intervention types and one control group - and their ongoing daily water consumption was monitored before, during and after the intervention. A notable aspect of this research was the extended period of time that households were monitored: household water consumption was tracked for up to 475 days after the start of the intervention.

- In the *information only* condition, households received general advice about how they could save water.
- In the *descriptive norm* condition, households received the general information about water saving along with information about other "low water use households" that used these same behaviours.
- In the *water end-use feedback* condition, households received the general water saving tips along with tailored information specifying where water was being used in their own household.
- The *control* group received no general water saving information.

The impact of the interventions (relative to the control group) were investigated with respect to four parameters: changes in daily water consumption over time, the relative cost-effectiveness of each intervention as a water-saving measure, changes in the use of water-using appliances over time, and changes in psychographic measures over time. Some of the analyses were hampered by reduced sample sizes, which resulted from households dropping out of the study over time – this drop-out was due to the failure of data monitoring equipment over time. Some units failed through normal wear and tear, and a number of units failed during the flooding that occurred in the study region in January 2011, after the intervention had concluded, but while long-term data collection was still under way.

Effects of Interventions on Daily Water Consumption

Longitudinal modelling showed that that the three interventions all resulted in significant reductions in household water consumption relative to the control group, and that these reductions were similar across the three intervention types. Meanwhile, the consumption in the control group households increased over the same time period. These results clearly support the contention that behaviourally-based interventions can contribute to marked reductions in domestic water consumption, even in a context of increasing consumption amongst non-intervention households. However, we found no clear evidence to distinguish the effects of one type of intervention from another (although we expected them to operate differently). Further, the water savings which result from these interventions all dissipated over time, with peak water savings at about four months after the end of the intervention, and a subsequent return towards pre-intervention levels. Even more than a year after the interventions, the intervention households had somewhat lower water consumption than comparable control households.

Cost-Effectiveness of Interventions

Cost-effectiveness was calculated using two different approaches: including and excluding the costs of instrumentation. If the cost of water use instrumentation is included in the calculations for all interventions, the information-only condition was the most cost-effective, although the water end-use feedback condition was comparable. If instrumentation costs are excluded, the information-only condition shows the best cost-effectiveness. Whether it is better to exclude or include instrumentation costs depends on a number of factors: whether multiple different interventions are being trialled, whether daily water use data is required, and what changes may be made to the "typical" instrumentation available in households in the future.

Effect of Interventions on Appliance End Use

Analysis of usage of eight different water-using appliances demonstrated changes in the intervention groups. Results showed that, in the control condition, there were no statistically significant changes in appliance usage over time. In the combined interventions condition, there were significant reductions over time in water used by showers, clothes washers and dishwashers, with showers and clothes washers demonstrating the largest reductions. Whilst all other appliances showed reductions in usage over time, those reductions were not statistically significant.

Effect of Interventions on Psychographic Measures

Apart from some minor differences in householders' perceived knowledge, analyses found no significant changes across any groups over time on relevant psychographic variables. Attitudes to water savings, perceived control, perceived norms and other variables were unchanged over time, for all groups. This result is counter to the expectation that respondents in the intervention groups would show changes on these measures in response to the interventions, and that only the control group would show no change over time.

Given that the behavioural impact of the interventions has been shown to have peaked at about four months after the intervention and declined thereafter, and that the post-intervention survey was also conducted during this decline (in March 2011), it may be that the intervention survey was conducted too late to reflect any substantive changes in psycho-social variables. We can speculate that the intervention did in fact influence psycho-social variables, but that these effects had dissipated along with behavioural changes by the time they were measured.

1. INTRODUCTION

A key platform of the South East Queensland Water Strategy is to delay the need for major water infrastructure through encouraging the community to use less water. Residential water use accounts for the major share of urban water use in South East Queensland (SEQ), therefore, developing and testing strategies that can encourage ongoing efficient use of water in households can contribute to the goal of reducing water grid demand.

This report describes the third stage in the Residential Water Demand Management component of the *Demand Management and Communication Research* project. The key aims of the project are to understand how households use water in their daily lives and how water conserving behaviours may be supported as a "way of life" in SEQ through a mix of interventions. Specifically, the project aims to:

- identify the psycho-social and socio-demographic drivers of residential water using practices;
- determine the effectiveness of targeted intervention strategies for achieving long term sustainable residential water use; and
- make a significant contribution to the scientific literature on water demand management.

The research project has proceeded in three stages.

1) The first qualitative stage identified salient beliefs associated with household water conservation (Fielding, Russell, and Grace, 2010).

2) The second phase involved a quantitative survey of free-standing owner-occupied households from the SEQ community. The aim of the research was to identify the key drivers, including the psychosocial and socio-demographic drivers, of residential water use. Two reports describe the results of the second phase of the research. The Part A report (Spinks, Fielding, Russell, and Mankad, 2010) describes analyses that examine the determinants of water conservation intentions. Intentions reflect community members' commitment to conserving water. The Part B report (Fielding, Spinks, Russell, and Mankad, 2012) identifies the demographic, infrastructure, and psycho-social drivers of households' actual water use, as measured by water utility data.

3) The third and final stage, described in this report, investigates the effectiveness of a range of possible intervention strategies for reducing household water use.

The current study represents an integration of a behaviour change study that draws on social science methods with a water end-use study. In addition to completing the baseline survey (i.e., second phase of research – see above) and a post intervention survey, the participating households had their council residential water meters replaced with smart water meters. This allowed us to collect daily total water consumption for each household, as well as the proportion of water used for a range of water-using appliances, (e.g., shower, toilet, clothes washer, taps, irrigation).

Three intervention strategies were trialled. The first was an ***information only*** intervention whereby households were sent monthly water saving information about how to reduce water use in the bathroom, laundry, kitchen, and through fixing leaks. Although past research has shown that information alone is rarely successful in motivating pro-environmental behaviour (Schultz, 2002), this intervention allowed us to disentangle the effects of the water saving tips from the focal intervention information (i.e., descriptive norms, water end use information – see below).

The second intervention group received the water saving information as well as ***descriptive norm*** information. The literature distinguishes between two types of norms: norms that describe what people should do (injunctive norms) and norms that describe what people actually do (descriptive norms) (Cialdini, Reno and Kallgren, 1990). Research has shown that receiving descriptive norm information about what others are doing can influence people's behaviour. For example, hotel guests who are asked to reuse their towels to protect the environment are more likely to do this if they are also told that other hotel guests reuse their towels (Schultz, Khazian, and Zaleski, 2008). Research has even shown that information about what others are doing is a more powerful tool for change than traditional appeals. For example, information about others' energy saving actions is more effective at reducing household energy use than appeals to save energy to protect the environment, save money, or to 'do your bit' (Nolan, Schultz, Cialdini, Goldstein, and Griskevicius, 2008).

The third intervention group received the water saving information and ***water end use feedback***. Households in this group were advised of their average daily water usage and they were provided with a pie chart that showed the proportion of water their household used in various water-using appliances (e.g., shower, taps, clothes-washer, etc). Past research has shown that feedback can be an effective tool for promoting conservation behaviour, especially when it is tailored to the specific recipient (Abrahamse, Steg, Vlek and Rothengatter, 2005).

The three intervention groups were compared to a ***control group***, which did not receive any information. The inclusion of a control group allows an assessment of whether changes in water use can be attributed to the interventions or whether any changes that occur in water use may have resulted from being part of the study or external events.

We hypothesise that there will be no change in water consumption in the control group and that the descriptive norm intervention group and the water end-use feedback group will show reductions in water consumption across the four month intervention period.

2. METHODS

2.1. Setting and Study Period

The study was conducted within four local government areas (LGAs) in the SEQ Region: Brisbane, Gold Coast, Ipswich and the Sunshine Coast. The overall study period is broken down into three components: 1) the pre-intervention period during which participants were recruited and baseline survey data collected (September 2009 – June 2010); 2) the Intervention period during which the interventions were implemented and initial outcome data collected (July 2010 to December 2010); and 3) the post-intervention period when additional outcome data were collected (January 2011 – December 2011).

2.2. Ethics

Ethical clearance for the study was provided by the University of Queensland Human Research Ethics Committee. Approval was also gained from CSIRO and Griffith University Human Ethics Committees.

2.3. Study Design

The study design used an experimental approach and consisted of a randomised controlled trial, testing three different interventions to reduce household water consumption. A control condition in which participants received no information or intervention was included in the study design for comparative analysis. Household water consumption data and appliance use data was collected using smart meters. Psychosocial data was collected using a postal survey pre- and post-intervention.

2.4. Study Population and Participants

2.4.1. Study Population Characteristics

Participants were those who had completed a Baseline Household Water Use Survey during 2009 (see Spinks *et al*, 2010) and indicated willingness to participate in further research. The targeted Baseline Survey population consisted of householders residing within the designated study region postcodes (see Spinks *et al*, 2010). Due to necessity of being able to access individual household water consumption data, targeted households were owner-occupiers of dwellings connected to the central water supply with an individual water meter attached to the premises (i.e., not a multiple-tenancy complex with shared / body corporate water records).

Participants recruited into the current study also participated in the South East Queensland Residential End Use Study (SEQREUS) conducted by Griffith University (see Beal, Stewart and Huang, 2010 for more detail). SEQREUS aimed to quantify water end-use in a sample of dwellings located in the study region, by replacing existing council water meters with 'smart' meters connected to data loggers, which recorded high resolution water use data. Specialised software was used in conjunction with water audits and water diaries to analyse the high resolution water use data and determine the amount of water being consumed by various water-using appliances in each household.

2.4.2. Participant Recruitment Procedures

Details on participant recruitment procedures for the Baseline Household Water Use Survey can be found in Spinks *et al*, (2010). Of 1749 households responding to the Baseline Survey, 948 indicated a willingness to be involved in further research and were accordingly sent a letter of invitation (see Appendix A). Participation in the research required: 1) replacement of their water meter with a 'smart' water meter, along with the conducting of a water audit in their home, and the completion of water diaries; and 2) participation in a trial to test household interventions to save water.

The letter of invitation included a consent form (see Appendix B) for participants to indicate their willingness to participate in the ongoing research, along with a reply paid envelope to return the consent form to the study research team.

A total of 400 consenting responses were received from the four study regions (Brisbane = 127, Gold Coast = 102, Ipswich = 73, Sunshine Coast = 98). Consenting households were then contacted by the SEQREUS Team from Griffith University to arrange for installation of the smart meters and data loggers. Due to technical issues affecting the suitability of smart meter replacement, not all willing households were able to be fitted with the meters. Further details about the smart meter installation and the associated home water audits can be found in Beal *et al.*, 2010.

A baseline water end-use data read and analysis was conducted by the SEQREUS Team in June 2010. In total, there were 221 households for which baseline end-use data analysis and Baseline Household Water Use Survey data were available. These households were included in the current study.

2.4.3. Randomisation of Participants to Interventions Conditions

Due to the small number of participating households in the Ipswich region, a decision was made to combine households within Brisbane and Ipswich to form one study area. A stratified randomisation approach was applied to randomise households within the three resulting study regions Brisbane-Ipswich, Gold Coast, and Sunshine Coast) and within broad household type (single person household, multiple adult household and households consisting of a family with children). A computer generated random sequence was used to allocate households to either the control group or one of three intervention groups:

1) Information only condition
2) Descriptive norm condition
3) Water end-use feedback condition

Households from all three regions were allocated to the descriptive norm, water end-use feedback and control treatment groups, however, the information only group only contained households from the Brisbane-Ipswich region.

2.5. Description of Interventions

Prior to the start of the intervention period, all participants received an initial letter (sent on September 6th, 2010) from the research team (see Appendix C). The initial letter provided general background information relevant to the study. There were two versions of the initial letter, one for the three intervention conditions and one for the control condition. These letters were identical and differed only in that participants in the intervention conditions were informed that they would receive information from the research team over the coming months. Both versions of the letter alerted participants that they would be asked to complete a final survey for the research in approximately six months time.

The interventions for the three experimental groups were implemented via a series of four postcards sent to each household. Each postcard provided information concerning ways in which to save water either in a particular location of the house (bathroom, laundry, and kitchen) or through checking and fixing leaks. The postcards were delivered over a four-month period:

- Postcard # 1: The Bathroom 13 September 2010
- Postcard # 2: The Laundry 11 October 2010
- Postcard # 3: The Kitchen 16 November 2010
- Postcard # 4: Fixing Leaks 10 December 2010

One side of each postcard was identical for all three experimental groups, and provided the general information on water saving (see Appendix D). The overleaf side of the postcard differed according to each experimental condition as described below.

2.5.1. Information Only Condition

The information only condition was included in the study design to allow the effects of receiving information about saving water to be separated from the effects of the specific intervention conditions (i.e. descriptive norm information and water end use feedback information). Therefore, the only information received by participants in this condition was on the first side of the postcard. The second side of the postcard was a larger version of the cartoon graphic used in the two previous experimental conditions (see Appendix D). Due to limited participant numbers throughout the entire study region, only a subset of participants in the combined Brisbane-Ipswich area were allocated to this condition.

2.5.2. Descriptive Norm Condition

The descriptive norm intervention was based on psychosocial theory and experimental evidence which indicates that individual behaviour is influenced by how people perceive the behaviour of other individuals who are similar to them. The intervention, therefore, aimed to provide participants with information about the sorts of actions that low water using households that were similar to theirs in terms of household composition (i.e., single person, multiple adults, or family with children) did to save water.

The second side of the descriptive norm condition postcards was, thus, comprised of two components: 1) a cartoon graphic depicting a water saving activity; and 2) statements about the percentage of low water using households who reported always or almost always performing a certain water saving behaviour (see Appendix D). These statements were derived from the results of the Baseline Household Water Use Survey in combination with water use data obtained from the water utilities, and were considered accurate representations of households in SEQ. For each of the four time points in the series, three different postcards were developed in accordance with the three household composition types. Each household allocated to the descriptive norm condition received the postcard that matched their circumstances.

2.5.3. Water End-Use Feedback Condition

The water end-use feedback condition aimed to provide participants with information about exactly how much water was used in various parts of their household. Participants allocated to this condition received individualised postcards with information derived from water end-use analysis performed by the SEQREUS team. For two of the postcards (#1 – Bathroom and #3 – Kitchen), this consisted of a pie chart showing a breakdown of household water along with the average daily per person usage (see Appendix D). Due to the time burden associated with performing the end-use analysis, it was not possible to provide this information at each time-point. Thus, the second postcard (corresponding to saving water in the laundry) reminded participants of the amount of water used in the laundry from the previous analysis; and the final postcard (corresponding to checking and fixing leaks) either reminded participants that a leak had been detected in their home or that one may occur in the future if no leak had been previously detected. The second side of the water end-use condition postcards also contained a cartoon graphic.

2.6. Data Collection

2.6.1. Baseline Household Water Use Survey

The Baseline Household Water Use Survey (see Spinks *et al.*, 2010) consisted of 27 multi-item questions (103 items in total) which were designed to elicit information from participants about various aspects of household water use and conservation, as well as standard demographic and household composition data. The majority of questions used the Likert Scale response format; however some open-ended and categorical multi-choice questions were also included.

2.6.2. Post-Intervention Household Water Use Survey

Two versions of the Post-intervention Household Water Use Survey were developed: one which included questions concerning the postcards used in the interventions (Version A); and one which did not included these questions but was otherwise identical (Version B). Version A of the survey was sent to participants in the three intervention conditions while Version B was sent to participants in the control condition. The main part of the survey consisted of twenty questions (58 items in total) focusing on various aspects of household water conservation and the extent to which householders were concerned about current and future water shortages. A question was also included to establish whether or not participants had been affected by regional flooding which occurred in January 2011. The four additional questions contained in Version A of the survey asked participants how they believed their households had responded to, or been influenced by, the information contained in the intervention postcards.

2.6.3. Household Daily Water Use and End-Use

Daily household water use for each participating household was provided by the SEQREUS team for the time period from June 1st, 2010 until March 31st, 2011. Water end-use data for each household were also provided for two periods: a 2-week period prior to the intervention (in June 2010); and another two-week period six months after the intervention (in December 2010/January 2011). Details regarding the collection of all these data can be found in Beal *et al.*, 2010.

2.6.4. Effect of January 2011 Floods

After months of heavy rainfall, severe flooding of the Brisbane and Bremer Rivers occurred on January 11th - 14th, 2011. Flood waters inundated many homes and businesses in Brisbane and Ipswich, with the damage and associated clean-up activity receiving widespread media coverage. These floods impacted on the timing and completeness of data collection for this project in the following ways:

- A significant number of smart water meters and data loggers installed in participant homes were destroyed or damaged by the floods and heavy rains, particularly in Ipswich and (to a lesser extent) Brisbane. As a consequence, the availability of household water use and end-use data declined rapidly after the floods occurred. Budget limitations meant that failed data monitoring equipment could not be replaced or repaired.
- Due to the physical, economic and emotional disruptions experienced by the community in the wake of the floods, a decision was made to delay the post-intervention survey which had initially been scheduled to be sent out two weeks after the flooding occurred. The survey send-out was delayed until March 31st, 2011.
- A decision was made to remove 27 households from the survey send-out, because they were known to have been inundated by flood waters.
- All remaining participating households were contacted by letter in March, 2011 to inform them of the upcoming survey (see Appendix E). This letter offered participants the opportunity to ‘opt out’ of receiving the survey, however no requests were received to this effect and so the survey was subsequently sent to all non-flood affected households.

3. RESULTS

3.1. Overview

Results are provided in four sections.

- Section 3.2 assesses the effect of the interventions on total daily water consumption.
- Section 3.3 presents an estimate of the cost-effectiveness of each intervention.
- Section 3.4 describes changes in water end-use related to the interventions.
- Section 3.5 presents analyses of the psychographic measures taken before and after the intervention.

Table 1 shows the number of study participants in each region at the outset of the study. Note that the information only condition contained households from the Brisbane/Ipswich regions only. Because of the limited size of the total sample of households, a decision made to restrict the size of the information only condition to enable larger sample sizes for the other conditions, which were deemed to be of more substantive interest. However, this decision did mean that the effects of region and intervention type were confounded. We addressed this issue by controlling for both region and intervention type in all relevant analyses, so that the impact of each of these factors could be assessed separately.

Table 1. Number of study participants in each region.

Treatment Group	Brisbane plus Ipswich	Gold coast	Sunshine Coast	Total
Descriptive Norm	24	19	22	**65**
Water End-use Feedback	26	18	22	**66**
Information Only	24	0	0	**24**
Control	24	19	23	**66**
Total	**98**	**56**	**67**	**221**

It is important to note that the available data varies for different analyses. Analyses of changes in total water consumption and appliance-specific water end-use are influenced by the decline over time of the number of operable water loggers (especially due to flooding in January 2011). Analyses of changes in psychographic measures are influenced by the substantial drop in sample size for the post-intervention survey. Table 2 displays the availability of different data from participating households over time.

Table 2. Numbers (and percentages) of participants available for different forms of data used in the study.

Treatment Group	Pre-Intervention	Post-Intervention			
	Baseline Survey data, daily water consumption, appliance end-use	Daily water use data (cases with >80% data in March 2011)	Post-intervention Survey data (March/April 2011)	Daily water use data (cases with >80% data in Dec 2011)	Water end-use data (Dec 2010 and Jan 2011)
Descriptive Norm	65	55 (85%)	45 (69%)	19 (29%)	47 (72%)
Water End-use Feedback	66	57 (86%)	52 (79%)	25 (38%)	55 (83%)
Information Only	24	22 (92%)	15 (63%)	8 (33%)	22 (92%)
Control	66	53 (80%)	53 (80%)	24 (36%)	49 (74%)
Total	**221**	**187 (85%)**	**165 (75%)**	**76 (34%)**	**173 (78%)**

3.2. Effect of Interventions: Daily Household Water Use

3.2.1. Measures

The initial Baseline Household Water Use Survey provided demographic information about household occupancy and household composition that enabled accurate calculation of per person water usage and descriptive norm information to be tailored to the household's specific composition. The number of residents recorded in the initial Household Water Use survey was validated in the follow-up contact with the households when smart water meters were installed.

The smart water metering data provided daily household water use for the pre-intervention, intervention, and post-intervention periods. It also provided the average per person per day water use data for the water end-use condition postcards #1 (Bathroom) and #3 (Kitchen).

3.2.1.1 Trend Daily Water Use per Person

Household water use typically shows large fluctuations over time, so to aid in analysis and display of data, we created a smoothed measure of per person water consumption. A simple 7-day moving average of daily water use per person was calculated, which smooths fluctuations in daily use data over the course of a week (the value for any particular day is the average of the previous seven days). This measure provides a lagged daily trend in water use which smoothes daily fluctuations in water use, reducing noise in the data (e.g. higher water use on weekends for some households). Per person estimates were derived from measures of total household water use divided by the number of persons in each household.

3.2.1.2 Baseline Water Use

To create a stable baseline for water use before the intervention period, average daily water use per person was calculated for 12 weeks prior to the interventions. We defined this as the pre-intervention period. This baseline was used as the first data point in longitudinal data analysis to stabilise estimates of initial water consumption (i.e., day zero in data analyses).

3.2.1.3 Day Number

Day numbers were designated as the number of days from the onset of the intervention period. The first day of the intervention period was 13 September, 2010 and this was denoted as day 1. Pre-intervention baseline data were gathered for the 84 days prior to day 1. The intervention period ran from day 1 to day 120 (10 January, 2011), with postcards delivered on days 1, 29, 65 and 89. The post intervention period ran from day 121 (11 Jan, 2011) to day 475 (31 December, 2011).

3.2.2. Overview of Analyses

The aim in this section is to analyse trends in daily water use for households over time. Growth curve modelling (also known as individual growth models or multilevel models for change) is employed for this analysis, since it has been specifically designed for modelling linear and curvilinear changes over time for continuous variables (Singer and Willett, 2005). Growth curve modelling, and multilevel modelling more generally, are extensions of regression analysis (Bickel, 2007) and have a number of advantages for modelling nested time series data: they control for auto-correlations between observations within units of analysis (i.e. consecutive daily observations of water use within households); they make use of information for each and every observation (i.e., water use information for each day for each household) thereby increasing the power of analyses; they actively model missing data instead of deleting cases with missing data.

Although growth curve modelling is very good at incorporating all available data, there are inevitably fewer data points at the end of longitudinal studies than at the start (in our case due to data loggers failing over time). Thus, growth curve estimates for the experimental treatment groups may be more precise at the beginning than at the end of the study. Nonetheless, growth curve modelling is fast becoming the model of choice for analysing panel, nested or longitudinal data (see Bickel, 2007; Rabe-Hesketh and Skrondal, 2005; Singer and Willett, 2003; Singer and Willett, 2005) and is being increasingly and rapidly employed in the social sciences (for some recent examples, see Bushway *et al.*, 2009; Phillips and Greenberg, 2008; Reinehr *et al.*, 2010).

Growth curve modelling describes linear or curvilinear changes in water use over time. Any water use savings associated with interventions may level out over time or even rebound to pre-intervention levels. To test for curvilinear effects over time, a squared term was included in the model for the number of days from the beginning of interventions (i.e., the day number squared). Including this term distinguishes a growth curve model from a standard random intercept multilevel model.

3.2.3. Descriptive Statistics

Table 3 shows that the mean trend water use per person in this study was 140.4 litres for all groups over the study periods. During the intervention period, the mean water use dropped by 11.3 litres per person per day compared to the pre-intervention period (142.5 litres to 131.2 litres). In the post-intervention period, the mean water use returned to pre-intervention levels. In each treatment group, the mean trend water use also dropped during the intervention period, although consumption increased again in the post-intervention period except for the information only condition. However, the data were also averaged over a considerable number of days in each period, many households had missing data, and apparent differences between intervention groups are also influenced by different starting levels of water consumption. Thus, the impacts of each intervention on water consumption cannot be clearly evaluated simply from an examination of the post-intervention averages. To more comprehensively model the changes in water use over time, longitudinal modelling was conducted.

Table 3. Mean Trend daily water use per person (litres) by intervention group and period.

Group	Time Period			Total	SD	Min.	Max.
	Pre-Intervention	Intervention	Post-Intervention				
Control	141.3	138.9	159.6	150.4	101.6	10	1,415
Information only	134.5	114.9	108.8	116.3	69.3	10	1,105
Descriptive norm	156.5	141.0	147.3	147.7	117.0	10	2,147
Water end-use	132.9	121.0	136.8	131.6	133.2	10	3,626
Total	142.5	131.2	144.4	140.4	114.7	10	3,626

3.2.4. Data Preparation

In Table 3, the standard deviation and maximum statistics for trend water use were all large, showing wide variation and high skewness in daily water use. Wide fluctuations and high skewness is problematic for modelling water use. Very high water use may occur during uncommon events like filling swimming pools and very low water use may occur when people are away (e.g., on holidays). To better account for days with extremely high water use, the log of trend water use was modelled. Days with very low water use (zero or near zero water use) were treated as missing values because they are likely to represent household absences. Near zero water use was defined as less than 10 litres per person per day. These data preparation steps enabled more accurate estimation of trend daily water use.

To further enhance the quality of estimates for trend daily water use over time, households which did not have at least 10 weeks of daily water use data were excluded from the longitudinal analyses. These ten weeks did not have to be consecutive nor did each week have to have data for every day of that week. However, households included in the analyses had some daily water use per person in at least 10 out of the 68 weeks in the intervention and post-intervention periods. This resulted in 38 of 221 households being excluded from longitudinal analyses, leaving 183 households in the analyses. The missing water use data was largely due to equipment failure of data loggers and was considered missing completely at random. Thus, missing data was not seen as influencing any parameter estimates in the longitudinal analysis.

Of the remaining 183 households, there were still some missing water use data, including those days with zero or near zero water use. A frequency distribution of the number of days with valid water use data for modelling showed that the minimum number of days for any household was 62 days; 25% had 135 days of data; 50% had 369 days; and 75% of the 183 households had water use data for every day of the intervention and post-intervention periods (475 days). Thus each household had a considerable number of days of water use data to model any missing values in time series data.

When interpreting the results, it is worth noting that the unit of analysis is the household while the dependent variable is the trend daily water use per person, derived by dividing household water use by the number of persons in each household.

3.2.5. Longitudinal Modelling

We conducted a random intercepts model of the trend daily water use per person while also estimating an average level of water use per household. Estimates of this average water use for each household were enhanced by using the baseline water use measure as the first observation in the time series of water use for each household. Covariates were then included to model trend water use per person over time. A covariate for the number of days from the start of the intervention period was included to estimate long-term linear trends in water use over the entire intervention/post-intervention period; and a covariate for number of days squared was included to estimate any non-linear changes in long-term water use.

The main independent covariate of interest was the intervention group (information only, descriptive norm, and water end-use feedback groups). A dummy variable was added for the intervention group to estimate whether these interventions varied significantly in water use at the start of the intervention period. An interaction term between the intervention group and day number was then added to estimate any linear changes in water use for each intervention group over time. Another interaction term was added between the intervention group and days squared to estimate any curvi-linear changes in water use over time for each intervention group. Lastly, a dummy variable for the four regions in this study was added to account for variations in water use that may exist between regions in SEQ.

Table 4 shows the results from this random intercepts model. The constant was significant (2.06; $p < .05$) indicating the mean level of *logged* trend water use per person, taking into account the other covariates. The value of 2.06 equates to an unlogged value of 115.24 litres per person per day. Since the log is used to normalise a skewed distribution, this figure of 115.24 litres per person per day can be thought of as an estimate of the median trend daily water use per person. Note that this median figure is lower than the more typically reported mean daily water consumption (140.4 L for these data), which (unlike the median) does not exclude the impact of a few households with very high water consumption.

The day number squared covariate was significant and positive, indicating an increasing trend in water use independent of the intervention groups. The coefficients for the different regions were not significant, indicating that none of the regions differed significantly from Brisbane in logged trend daily water use per person at the beginning of the intervention. The main effects for the intervention groups were also not significant, indicating, as expected, that none of the intervention groups were significantly different in water use at the start of the intervention period compared to the control group.

The coefficients for 'intervention by day number' were significant and negative for the 'water end-use', 'descriptive norm' and 'information only' groups, indicating a negative linear trend or decreasing consumption of daily water use per person over time for these interventions. However, this trend was qualified by significant positive coefficients for these groups for 'intervention by day number squared', indicating a concave non-linear trend, such that the decrease in consumption dissipates over time. This effect can be seen in Figure 1.

Figure 1 shows estimates from the random intercepts model re-expressed in litres per person per day over the intervention and post-intervention periods. The inverse logarithms of the coefficients in Table 4 have been taken to estimate water use in litres for each intervention and day. The model was based on logged data to meet assumptions for normally distributed random errors and intercepts. However, the same model using unlogged data showed the same general pattern of results.

The control group significantly increased in trend daily water use over time. The other groups decline significantly during the initial intervention period. However, by about 3-4 months after the intervention period they all begin to increase water use again, eventually losing the gains made during the intervention period after 6-10 months. The curves for these treatment groups are not significantly different from each other, although the curvature in the line for the control group is significantly different from the other groups (all *p*'s $<.05$).

Table 4. Random intercept model of logged trend water use per person.

Effect	b coefficient	*z*-value	*p*-value
Constant	2.061616	51.58	0.00
Day no.	-0.000070	-1.80	0.07
Day no. squared	0.000000	5.42	0.00
Intervention groups (c.f. control)			
Water end-use	-0.001620	-0.04	0.97
Descriptive norm	-0.042800	-1.08	0.28
Information only	-0.041122	-0.72	0.47
Intervention x day no. (c.f. control)			
Water end-use	-0.000418	-7.49	<.01
Descriptive norm	-0.000238	-4.13	<.01
Information only	-0.000457	-5.67	<.01
Intervention x day no. squared (c.f. control)			
Water end-use	0.000001	6.06	<.01
Descriptive norm	0.000001	4.69	<.01
Information only	0.000001	3.68	<.01
Region (c.f. Brisbane)			
Gold Coast	-0.010712	-0.25	0.80
Ipswich	-0.015355	-0.32	0.75
Sunshine Coast	0.051045	1.20	0.23

Notes: water use observations = 58203; households = 183; observations per household = 318 on average (min = 62; max = 476).

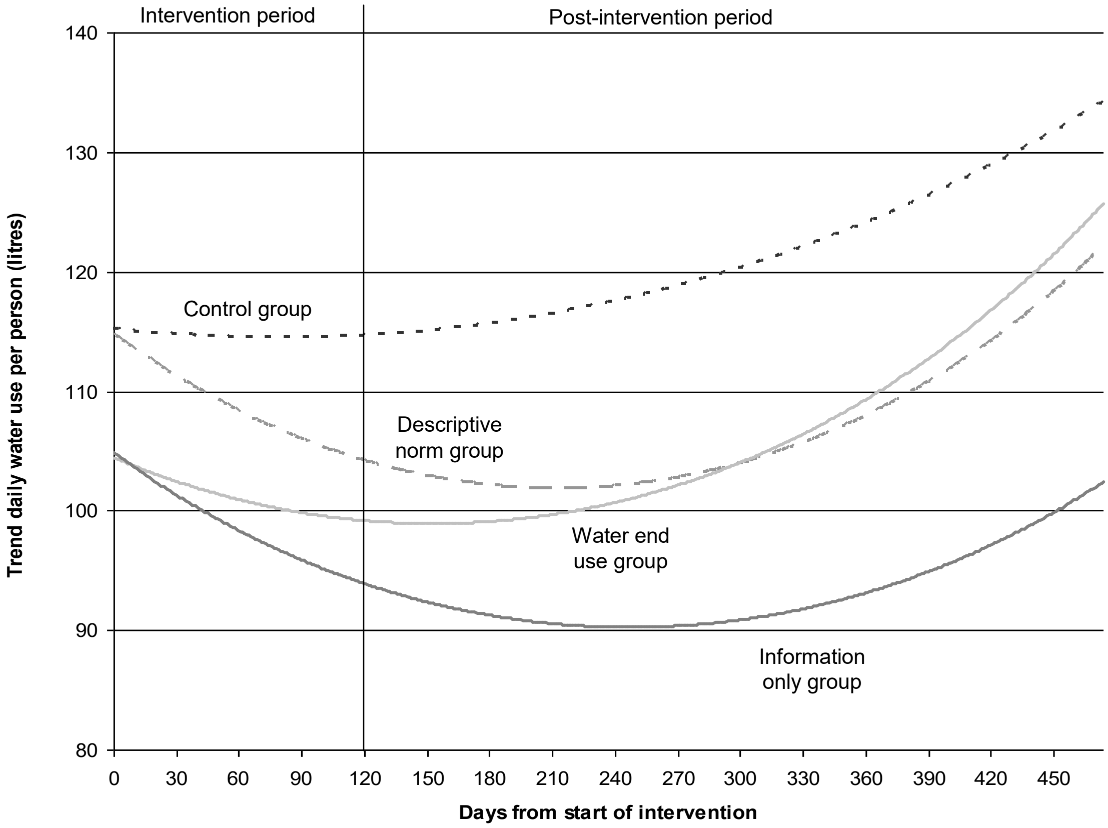


Figure 1. Trend daily water use per person (litres) for intervention and post-intervention periods.

3.2.6. Summary

Overall, we can conclude from the longitudinal modelling that the three interventions all resulted in significant reductions in household water consumption, and that these reductions were not meaningfully different across the three intervention types. These results support the contention that behaviourally-based interventions can result in marked reductions in water consumption. Furthermore, these reductions took place in a context of increasing water consumption in the control households, so the interventions not only arrested but reversed the observed trend of consumption amongst comparable households. However, we have found no clear evidence to distinguish the effects of one type of intervention from another. Further, the water savings which result from these interventions all dissipated over time, with peak water savings at about four months after the end of the intervention, and a return to pre-intervention levels after about one year. It is important to acknowledge that these interventions led to substantial water savings over time, and even though their impacts faded, the intervention households were still showing lower water consumption than the control households more than a year after the end of the interventions. The next section of the report attempts to quantify the extent of the water savings generated by the interventions.

3.3. Cost-Effectiveness of Interventions

3.3.1. Overview

In order to assess the cost-effectiveness of the three interventions, we needed to:

- Estimate the costs per household required to conduct each intervention,
- Estimate the average water savings per household for each intervention,
- Calculate a cost-effectiveness figure (expressed as dollars per kilolitre of water saved).

It is important to note that this process is based on some major assumptions and exclusions, and that figures generated are in part reflective of the scale of the current study; thus the results should be treated as rough estimates only. Their value is primarily in providing an assessment of the relative cost-effectiveness amongst the three different interventions used in this study. Any comparison with cost-effectiveness data from other studies and/or other intervention types, especially if they were undertaken at a different scale, may be misleading.

3.3.2. Estimated Costs

To estimate intervention costs, we identified all the project spending that was directly related to conducting the interventions. The consideration here was to get a best estimate of what it would cost for another, similar intervention to be conducted in the future. Thus, costs were assessed for recruitment of participants, design and production of intervention materials, installation and maintenance of data loggers, and (for the end-use feedback condition) staff time for the processing and analysis of end-use data.

Apart from end-use data analysis, we had no clear way to estimate the amount of staff time that went into each intervention for general administrative and management tasks, so staff time of this sort is excluded from the calculations. It's noted that staff time would not scale well with size of the intervention: relative time required to deal with each household becomes smaller when there are more households involved.

We also excluded $5,400 in graphic design costs, because although this cost was a major component of the creation of intervention materials, such a cost does not scale linearly with volume, and for larger-scale interventions these costs would represent a negligible proportion of total cost. Other costs related to the creation of the intervention material are also not easily assessed: in particular, the figures for typical water consumption for different household types that were cited on the intervention postcards were generated from survey research conducted as a part of the larger demand management project. Such figures would represent another cost (not included here) that would be incurred if this intervention were to be replicated in another context.

Finally, it is noted that the majority of the intervention costs stem from the provision of smart water meters and data loggers for recording daily water consumption. Whilst this instrumentation was a primary component of the present study, future interventions do not necessarily require the presence of this infrastructure. A descriptive norm or information-only intervention could be provided without information about daily water usage, but clearly an intervention involving end-use feedback would require such data. However, any intervention that wanted access to daily household usage data to provide an accurate and long-term assessment of water saving outcomes would require the installation of comparable meters and loggers. To address this complexity, we report two sets of cost-effectiveness figures: one that includes the cost of instrumentation, and one that excludes this cost. Details of all cost estimates are shown in Table 5 (all figures are in 2010 dollars).

Table 5. Estimated costs for various components of the interventions.

Intervention Component	Total Costs	Per-Household Costs for Each Group			
		Control[1]	Information only	Descriptive Norm	Feedback
Recruitment of participants	$ 1,940	$ 8.78	$ 8.78	$ 8.78	$ 8.78
Print and post invitation letter	$ 1,601				
Reply-paid envelopes (printing)	$ 163				
Reply-paid envelopes (postage)	$ 176				
Preparation of intervention materials[2]					
Printing costs	$ 3,000	N/A	$18.07	$18.07	$18.07
Intervention					
Initial letter	$ 135	$ 0.61	$ 0.61	$ 0.61	$ 0.61
Postcards (x 4)	$ 400	N/A	$ 2.41	$ 2.41	$ 2.41
Processing of end-use data for feedback[3]	$ 11,000	N/A	N/A	N/A	$49.77
Smart meters/data loggers (purchase, installation, maintenance)		$1,000	$1,000	$1,000	$1,000
Totals		**$1,009**	**$1,030**	**$1,030**	**$1,079**

1 The control group received no intervention materials beyond the initial letter.
2 Graphic design costs are not included, since they do not scale with volume of households.
3 Although end-use processing was conducted on all intervention conditions in the present study, these costs are only displayed for the end-use condition, because this is the only condition that requires such analyses.

3.3.3. Estimated Water Savings

To estimate the water saved by each intervention, we calculated the total amount of water used over the entire intervention period (13 September 2010 to 10 January 2011). An average per-household usage figure was calculated for each intervention group, as well as the control group. Since the four groups did not have exactly the same water use figures at the outset of the intervention, the figures were corrected for these initial differences. Then, the differences between each of the intervention groups and the control group were calculated, as follows:

- Information only: 7,053 litres per household
- Descriptive norm: 1,794 litres per household
- Water end-use feedback: 5,720 litres per household.

Since each of the intervention groups used less water than the control group, the figures above all represent water savings relative to the control group. The substantially lower figure shown for the descriptive norm intervention is noteworthy. Examination of the data suggested that the households in this condition (relative to the other conditions) included more cases of high and extremely high water consumption on particular days within the data set, and hence a lower figure for average water saved.

It is noted that we could have estimated average water savings over a longer time period (up to 475 days after the outset of the intervention). Obviously, water savings relative to the control group calculated in this manner would have been larger, since the control group uniformly increased in consumption over time, and the intervention groups all decreased initially until about March/April 2011, and then gradually increased. However, as noted earlier, the quality of the data systematically declined over time as more water loggers failed, so that the final estimates of water savings would have been much less reliable. In addition, the flooding that occurred in January 2011 probably had a substantial influence on subsequent water consumption. On balance, we judged that January 10 was the most appropriate cut-off to use for water saving estimates.

3.3.4. Calculations of Cost-Effectiveness

Cost-effectiveness calculations are shown in Table 6. As noted above, we produced two figures: one that included the costs of instrumentation, and one that excluded these costs. If instrumentation is included for all interventions, the information-only condition is the most cost-effective, although end-use feedback is fairly similar. If instrumentation is excluded, the information-only condition shows the best cost-effectiveness. Whether it is more appropriate to exclude or include instrumentation costs depends on a number of factors: whether multiple different interventions are being trialled, whether daily water use data is required, and what changes may be made in the "typical" instrumentation available in households in the future.

Because the information only and descriptive norm conditions have equivalent costs, with the only difference being the nature of information that is provided in each case, their different cost-effectiveness depends only on our measure of the water savings they generated. Although we expected the descriptive norm to be more effective, it did in fact produce substantially smaller water savings than the information-only intervention, and thus it has a poorer cost-effectiveness estimate.

Table 6. Cost-effectiveness for the three interventions (including and excluding the cost of instrumentation).

Intervention	Cost to Implement ($ per household)	Estimated Water Savings (kL per household)*	Cost Effectiveness ($/kL)
Including instrumentation			
Information only	$1030	7.05	$146.10
Descriptive norm	$1030	1.79	$575.42
Water end-use feedback	$1079	5.72	$188.64
Excluding instrumentation			
Information only	$30	7.05	$4.26
Descriptive norm	$30	1.79	$16.76
Water end-use feedback	$79	5.72	$13.81

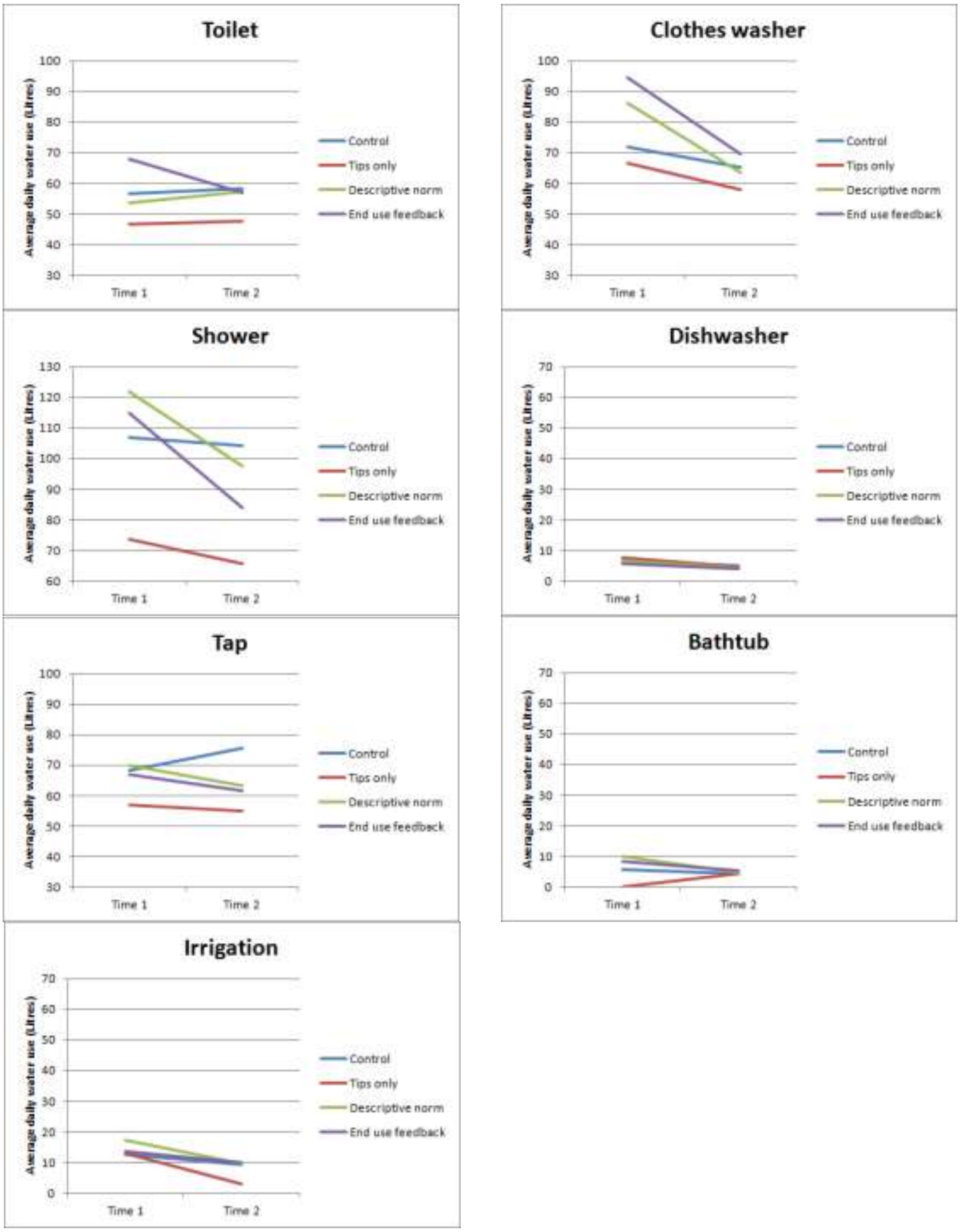
* Note that this figure represents estimated savings over 120 days.

3.4. Effect of Interventions: Water End-Use

Smart Meter readings for water using appliances were taken across two time periods for all households participating in the intervention study and used in analysis. Both of these time periods spanned two weeks, the first occurring immediately prior to the intervention (in June 2010: Time 1), and the second about a month after the intervention had been completed (in December 2010/January 2011: Time 2). Trace analysis was then performed on the smart meter data to determine the amount of water that had been used across seven separate water using appliances/functions in each household: toilet, clothes washer, shower, dishwasher, tap, bathtub and outdoor irrigation. Leaks were also identified as a separate "function", but since they represent an involuntary use which approaches zero for most households, they are not included in the analyses below.

Figure 2 shows the estimated means at Time 1 and Time 2 across the four intervention conditions (Control, Information Only (Tips), Descriptive Norm and Water End-use Feedback) for the amount of water used across each of the seven appliances.

Figure 2. Changes over time in estimated household daily water consumption per appliance.



Compared to the control condition, and correcting for extreme values, all interventions produced roughly comparable reductions in household water consumption over time. Due to this similarity, and to counteract the effects of reduced sample sizes at Time 2, data from the three intervention groups were combined. The changes over time across the 'Control' and 'Combined Interventions' conditions are reported in Table 7. This table shows the estimated mean daily water use (controlled for number of residents) across the seven appliances at Time 1 and Time 2.

Table 7. Estimated mean household daily water use (litres) across seven household appliances for control and combined intervention groups.

Appliance/ Function	Control		Combined Interventions	
	Time 1	Time 2	Time 1	Time 2
Toilet	56.83	58.46	58.70	55.53
Clothes Washer	72.03	65.29	86.28	65.33*
Shower	107.42	104.55	110.06	85.81*
Dishwasher	6.53	5.17	6.46	4.34*
Tap	68.44	75.68	66.36	61.12
Bathtub	5.75	4.34	7.71	4.86
Irrigation	12.57	9.48	14.91	8.57

* Changes over time are significant at $p < .01$, using logged data.

Due to substantial skewness in the water usage measures, the appliance water use data for each household were logged for all subsequent analyses. A multivariate analysis of variance (MANOVA) was performed which compared the control and combined intervention conditions for the amount of water used at Time 1 and Time 2 across the seven appliances. The analysis included the number of people residing in the household as a covariate. Results showed that in the control condition, there were no statistically significant changes in appliance usage over time. In the combined interventions condition, there were significant reductions over time in water used by showers, clothes washers and dishwashers, with the first two demonstrating the largest reductions. Whilst all other appliances showed reductions in usage over time, these reductions were not statistically significant. In contrast, the control condition showed no significant changes in usage for any appliances over the same time period.

3.5. Effect of Interventions: Psychographic Measures

3.5.1. Overview

This section describes analyses of the psychographic measures from the two written surveys, the baseline survey was conducted several months before the intervention (in March/April 2010), and the post-intervention survey was conducted a year later in March/April 2011. As noted previously, there was a substantial drop in data availability for the second survey, primarily as a result of the flooding in the study area in January 2011.

3.5.2. Data Preparation

Scales were constructed by averaging the scores on each of the applicable items, with the exception of one scale in which the two items were added together (due to having different response scales). Scale reliability was assessed using Cronbach's alpha (if more than two items) or Pearson's r (if only two items). Table 8 shows the reliability of the scales used in the study. Refer to Appendix F for more detail on scales used in the study.

Table 8. Reliability of scales.

Scale	Number of Items	Reliability at Baseline	Reliability Post Intervention
Attitudes	4	.69	.83
Subjective norms	3	.64	.67
Moral norms	3	.81	.79
Perceived behavioural control	3	< .001	.43
Self-identity	2	R = .76, p < .01	r = .73, p < .01
Community identity	3	.91	.91
Curtailment household culture	4	.93	.99
Efficiency household culture	4	.90	.99
Protection motivation theory variables	4	.87	.88
Manipulation check – water end-use	2	-	r = .21, p < .01
Manipulation check – descriptive norm	3	-	.49

3.5.3. Manipulation Checks

Manipulation checks were conducted to determine if participants in the water end-use feedback group reported more knowledge of their water end-use post intervention compared to the other groups. One-way analysis of variance revealed a significant difference between groups on the water end-use manipulation check scale ($F(3, 161) = 2.898$, $p = .037$). A one sample t-test was conducted to compare the mean of the water end-use group with the mean of the descriptive norm, information only, and control groups. The t-test revealed a significant difference, $t(51) = 5.018$, $p < .001$, such that the water end-use feedback group scored significantly higher ($M = 8.33$) than the other three groups ($M = 7.58$) on the water end-use items. In other words, compared to the information only, descriptive norm, and control groups, the water end-use feedback group reported that they had more knowledge about where most water is used in their household, and that their knowledge had improved significantly compared to 9 months ago.

Manipulation checks were conducted to determine if participants in the descriptive norm group reported more knowledge of how other people use water (descriptive norm) post intervention compared to the other groups. Due to the low reliability of the descriptive norm manipulation check scale ($\alpha = .493$), the items had to be analysed individually.

A one sample-t-test was conducted to compare the mean of the descriptive norm group with the mean of the water end-use, information only, and control groups, for the first descriptive norm item. The t-test revealed a significant difference, $t(44) = 2.515$, $p = .016$, such that the descriptive norm group scored significantly higher ($M = 5.18$) than the other three groups ($M = 4.70$) on the first descriptive norm item, 'knowledge you feel you have about what households like yours do to save water'.

A one-sample t-test was conducted to compare the mean of the descriptive norm group with the mean of the water end-use, information only, and control group, for the second descriptive norm item. The t-test revealed no significant difference, $t(44) = .958$, $p = .343$. The descriptive norm group did not score significantly higher ($M = 2.36$) than the other three groups ($M = 2.28$) on the second descriptive norm item, 'compared to nine months ago, do you think your awareness of what other households do to save water is…'.

A one-sample t-test was conducted to compare the mean of the descriptive norm group with the mean of the water end-use, information only, and control groups, for the third descriptive norm item. The t-test revealed no significant difference, $t(44) = .979$, $p = .333$. The descriptive norm group did not score significantly higher ($M = 2.96$) than the other three groups ($M = 2.75$) on the third descriptive norm item, 'how much do you believe you are influenced by what other households like yours do to save water?'

3.5.4. Analysis of Baseline Psychographic Differences between Groups

Before the main analyses were conducted, we wanted to ensure that there were no significant differences in demographics between the control and intervention groups at baseline. A one-way analysis of variance was conducted to determine if there was any unwanted relationship between age and treatment group. There was no relationship between age and treatment group, $F(3, 211) = .882$, $p = .451$. A chi-square test for independence was conducted to determine if there was any unwanted relationship between gender and treatment group. There was no relationship between gender and treatment group (Pearson chi-square (3, n = 221) = 4.317, p = .229).

A chi-square test for independence was conducted to determine if there was any unwanted relationship between income and treatment group. The data was re-coded into three groups, low (less than $60,000), medium ($60,000 - $89,999), and high ($90,000 or more). A chi-square test for independence was then conducted on the re-coded data for income. The results revealed that there was no relationship between income and treatment group (Pearson chi-square (6, n = 194) = 12.143, p = .059).

A one-way analysis of variance was conducted to determine if there was any unwanted relationship between education and treatment group. There was no relationship between education and treatment group, $F(3, 216) = 1.485$, $p = .220$. A chi-square test for independence was conducted to determine if there was any unwanted relationship between household type and treatment group. There was no relationship between household type and treatment group (Pearson chi-square (9, n = 220) = 6.816, p = .656).

To check for differences between groups on any of the psychological variables at baseline, several one-way ANOVAs was conducted. There were no differences on any of the psychological variables between groups at baseline (Table 9).

Table 9. Summary of ANOVAs conducted to check for any differences in psychological variables between groups at baseline.

Variable	F	P	Df	Welch	p	df
Attitudes*	~~.286~~	~~.835~~	~~3, 217~~	.355	.785	3, 90
Subjective Norms	1.553	.202	3, 216			
Moral Norms*	~~1.709~~	~~.166~~	~~3, 217~~	1.184	.321	3, 83
Descriptive Community	.570	.635	3, 214			
Perceived behavioural control - efficacy	1.797	.149	3, 215			
Perceived behavioural control - control 1	1.285	.281	3, 215			
Perceived behavioural control - control 2	.170	.917	3, 216			
Self-identity	.996	.396	3, 217			
Community identity *	~~.330~~	~~.804~~	~~3, 217~~	.289	.833	3, 84
Curtailment household culture *	~~1.022~~	~~.384~~	~~3, 186~~	.704	.553	3, 74
Efficiency household culture	.611	.608	3, 186			
Protection motivation theory variables	.832	.478	3, 217			

*Variable violated the assumption of homogeneity of variances, refer to Welch values.

3.5.5. Analysis of Psychosocial Changes over Time

Analyses were conducted to determine if there was a significant difference in any of the psychological variables between the baseline survey and the post intervention survey (Table 10). For some variables the data cannot be interpreted, due to differences in sample sizes between treatment groups. Specifically, the information only group has fewer participants compared to the other three groups.

Table 10. The mean and standard deviation for each survey scale at baseline and post intervention.

Scale	Mean (SD) at Baseline	Mean (SD) Post Intervention
Curtailment attitudes	6.34 (0.56)	5.90 (1.20)
Curtailment subjective norms	5.77 (0.85)	5.40 (1.03)
Curtailment moral norms	6.21 (0.78)	5.98 (0.87)
Perceived behavioural control	6.08 (0.95)	5.90 (1.05)
Self-identity	6.03 (0.73)	5.98 (0.81)
Community identity	5.09 (1.30)	4.97 (1.28)
Curtailment household culture	5.90 (0.83)	5.21 (1.90)
Efficiency household culture	5.89 (0.80)	5.03 (2.12)
Protection motivation theory	5.07 (1.17)	4.42 (1.20)
Manipulation check – water end-use	-	7.86 (1.47)
Manipulation check – descriptive norm	-	10.01 (2.79)

A series of one-way analysis of variance were conducted to determine if there were any differences between treatment groups on any of the psychological variables post intervention. These analyses revealed no significant differences on any of the psychological variables between groups post intervention (Table 11).

Table 11. Summary of ANOVAs conducted to determine any differences in psychological variables between groups post intervention.

Variable	F	p	df	Welch	p	Df
Curtailment attitudes*	.493	.687	3, 161	.950	.422	3, 65
Curtailment subjective norms	1.513	.213	3, 161			
Curtailment moral norms*	1.261	.290	3, 161	.563	.642	3, 50
Perceived behavioural control	2.033	.111	3, 161			
Self-identity*	.294	.830	3, 161	.202	.894	3, 51
Community identity	.242	.867	3, 161			
Curtailment household culture	.207	.891	3, 161			
Efficiency household culture*	2.967	.034	3, 161	1.105	.356	3, 51
Protection motivation theory*	1.906	.130	3, 217	1.141	.338	3, 82
Manipulation check – water end-use	.826	.481	3, 211			
Manipulation check – descriptive norm	.530	.663	3, 161			
Curtailment attitudes	.904	.440	3, 161			

*Variable violated the assumption of homogeneity of variances, refer to Welch values.

3.5.6. Summary

These analyses were hampered by the substantial reduction in sample size between the pre-intervention and post-intervention surveys. Analyses show some small differences in householder's perceived knowledge depending on what intervention group they were in: respondents who received the end-use feedback reported more knowledge of how most water was used in their house, and respondents in the descriptive norm condition (who received information about other households like theirs during the intervention) reported more knowledge of other households like theirs do to save water.

Further checks showed that there were no substantive differences between groups before the beginning of the intervention and that random assignment of households to different intervention groups had been achieved, producing groups that were comparable to each other on a range of background demographic and psychographic measures.

However, and most centrally, analyses found no significant changes across any groups over time on relevant psychographic variables. Attitudes to water savings, perceived control, perceived norms and other variables were unchanged over time, for all groups. This result is counter to the expectation that respondents in the intervention groups would show changes on these measures in response to the interventions, and that only the control group would show no change over time.

Given that the behavioural impact of the interventions has been shown to have peaked about 3-4 months after the intervention and declined thereafter, and that the post-intervention survey was also conducted at about the same time as the decline (in March/April 2011), it may be that the intervention survey was conducted too late to reflect any substantive changes in psychosocial variables. We can speculate that the intervention did in fact influence psycho-social variables, but that these effects had dissipated along with behavioural changes by the time they were measured.

4. DISCUSSION AND CONCLUSIONS

If we are to ensure future urban water security, effective approaches to manage urban water demand are required. The current study demonstrates that even in a population where water use is already low, voluntary demand management strategies can promote further water savings. It is the first study to test the effects of these voluntary demand management strategies in relation to water conservation and to test the effectiveness of these strategies over a period of more than a year (475 days).

Compared to a control condition, all three voluntary strategies were effective in reducing household water consumption, even in the context of low pre-existing levels of household water use, high levels of rainfall during the intervention period, and increasing water consumption amongst non-intervention households. By the end of the intervention period, the dams in SEQ were all full to overflowing. Despite this, water use in the intervention households remained relatively low for some months after the intervention period. However, in the context of continuing high dam levels, household water use returned to pre-intervention levels by 6-10 months after the interventions ended, while over the same period, consumption in control households had climbed higher. These results suggest that voluntary demand management strategies can be effective over the short to medium term, but their longer-term effectiveness may depend on the continued implementation of strategies and/or a context of water scarcity.

The finding that the provision of procedural information (the information only condition) was as effective as approaches that combined procedural information with descriptive norm information or water end-use feedback is somewhat surprising in light of critiques of educational approaches to behaviour change (Geller, 2002; McKenzie-Mohr and Smith, 1999; Schultz, 2002). One reason for the effectiveness of the information only approach may be recent experience of drought in the region. Nieswiadomy (1992) found that water conservation education programs were only effective in regions of the U.S. that experienced water shortages. In the current study, householders had previously experienced serious drought conditions and despite recent high rainfall, it was likely that water conservation remained a salient and personally involving issue and engaging in water conservation activities was considered normative. Information provision may have been effective because it reinforced existing water conservation norms. These findings highlight the importance of approaches that communicate the precious and finite nature of water and the need to foreground water security as a critical issue.

Just as personal involvement with water issues may have increased the effectiveness of the information approach, this same factor may have made it less likely for descriptive norms and water end-use feedback to augment the effects of procedural information. Households who received descriptive norm information or water end-use feedback showed a similar pattern of water use to the information only group. Research by Göckeritz *et al.* (2010) shows that higher personal involvement with energy conservation weakened the relationship between descriptive norms and energy conservation. In a similar vein, Schultz *et al.* (2007) have shown that higher energy users - potentially households who are less engaged with this domain - are more responsive to social normative information. Given that it is people who are interested in water conservation who agreed to take part in the study, this high level of involvement may account for the lack of definitive results for descriptive norms or water end-use feedback. On the basis of our findings, we can speculate that the use of descriptive norms or water end-use feedback may be more effective for people who are less engaged with water conservation. This is an important consideration given that policy-makers are often trying to reach households who are less engaged. Further empirical research is necessary to examine the differences in effectiveness of these types of interventions across more and less engaged households.

A further consideration in relation to the effects of water end-use feedback is the lag between water use and receiving feedback about that water use. Geller (2002) has proposed that feedback should ideally be given as close as possible to behaviour and past research has demonstrated the effectiveness of frequent feedback in relation to reducing household energy use (Abrahamse *et al.*, 2005). Results from the present study showed that delayed feedback about how water is used in the home can be effective; however, it is possible that more immediate water end-use feedback may be even more effective. Current smart water metering technology does not allow real-time feedback to householders but this may be possible in the future with the development of more sophisticated water end use monitoring technology.

Our data also show that while the reduction in water use resulting from the intervention was maintained for some time after information provision ceased, household water use gradually returned to pre-intervention levels. These data suggest that although people often perceive that they are doing all that they can to save water (Walton and Hume, 2011), if they are motivated and provided with effective information they can achieve even greater reductions. Once the information campaigns are removed, though, it may require environmental cues like drought or water scarcity to facilitate the maintenance of behaviours that achieved the reductions demonstrated in the current study. Our householders experienced the opposite - floods and full water reservoirs during and after the study - and given these conditions there is the potential for the intervention approaches we trialled to have greater impact during conditions of water scarcity (Nieswiadomy, 1992; Trumbo *et al.*, 1999), yet this remains an empirical question.

4.1. Limitations of the Study

Despite these promising findings, a number of limitations of the study must be acknowledged. As we note above, people who agree to be part of a study on water conservation may be more engaged with the issue and this level of engagement may moderate their responses to intervention information. Future research that explores the role of water conservation attitudes and involvement in moderating responses to demand management interventions would be of value in this area.

There is also the possibility that it was the experience of being part of the study and knowing that they were being monitored that influenced householders' behaviour rather than the interventions. The inclusion of a control group who also knew they were part of a study but did not change their behaviour argues against this possibility. Moreover, households did not show immediate rebound effects after the intervention period ceased, even though they ceased to receive communication from the researchers. Taken together, our findings do not suggest that the outcomes were attributable simply to being monitored.

The climatic context of high rainfall during the study and the stability of water use in the control group also rule out the idea that changes in water use are due to outdoor irrigation related to seasonal changes.

A final limitation is that the information only condition was only comprised of residents of Brisbane and Ipswich, regions that were most affected by drought conditions and associated water restrictions. As we have reasoned above, the efficacy of the information only approach may be in part due to the higher level of engagement with water conservation of households in this region given their prior experiences.

4.2. Conclusions

Ensuring future water security in urban areas is a critical issue. There is ample evidence that demands on freshwater resources are unsustainable and will be exacerbated in the future by population growth, urban development and climate change. As a significant proportion of water is used by residents in urban areas, managing demand at the household level is crucial. Demand management strategies that promote household water conservation are a no-regrets solution to securing future water supplies, especially when they result in long-term shifts in attitudes and behaviour. Moreover, voluntary demand management strategies can complement a range of other strategies such as regulation and water efficient infrastructure, ensuring that they are optimally effective.

APPENDIX A. Study Information Sheet

INFORMATION SHEET

Systematic Social Analysis of Household Water Use

Thank you for recently completing the Household Water Survey. The information you provided will help government and water policy makers to ensure that there will be enough water for the community in the future.

We would like to invite you to take part in some further research that we are conducting. Your participation is entirely voluntary and you can nominate that you would like to be involved by completing and returning the enclosed form.

What type of research is being conducted?
We are asking people if they would like to be involved in two further phases of the research: *Strategies to Save Water,* and a *Water End Use Study.* This research will require very little time commitment on your part.

We would like as many people as possible to participate in *Strategies to Save Water*, however we are only able to include a limited number of people in the *Water End Use Study.* We will select these people based on different factors such as how many people live in the household and the geographical location of the house.

What do I have to do if I choose to participate?
The *Strategies to Save Water* study will take place in early – mid 2010 and will involve:
1) Providing you with different ways that will help you save water in your house and garden. This may include the provision of information and advice, feedback about the amount of water you are using or installing small water efficient devices in your home.
2) Completion of two household surveys that will be similar to the survey that you have already completed, but much shorter.

The *Water End Use* study will involve:
1) The *Strategies to Save Water* items listed above
2) Installation of a high resolution water meter (to replace your existing one) and a data logger at your home. The replacement of water meters has been approved by city council and will not cost you anything. The meter will be installed by a qualified technician in late 2009 - early 2010.
3) A one-off internal house assessment on water devices within your home and a flow trace analysis on water devices. This will be arranged at a suitable time for you (weekdays or weekends, morning or night) and will be conducted by a trained and professional research team member. This will occur only once at the start of the study with no further requirement to enter your house.

Additional information about the water meter replacement and flow trace analysis is provided on the following pages. If you are selected to be part of the Water End Use Study, you will receive a $20 voucher.

Does the research team require access to my property?
The research team will require access to your property only if you are selected to be part of the *Water End Use Study* for the following activities:
- Performing an assessment and flow trace analysis of water devices in your home. The flow trace analysis will simply involve running the shower for a few minutes to determine the flow rate.
- Replacing the water meter connected to your house. Your water meter is located near the boundary of your property and this activity should not impact on you in any way.

Are there any risks involved in taking part in the study?
We do not anticipate any risks associated with this research. If you have any concerns about any aspects of the study, please contact Dr. Anneliese Spinks (see next page for contact details).

What do I do if I decide I don't want to be part of the study anymore?
You are free to withdraw from the study at any time without explanation and you will not be penalised for doing so. If you decide to withdraw, you can ask for any or all of your data to be removed from the study. Simply contact Dr. Anneliese Spinks (see next page for contact details).

Will my information be kept private?
All information collected will be stored in a secure database with access only by the research team. Your information (survey responses and water meter readings) will be completely confidential and will only be used for the purposes of this research project. The data will be released only as summaries in which no individual's name, property or survey responses can be identified. Data taken from this study will

NOT be used for water billing or regulation purposes. Data will ultimately be used to develop more efficient and sustainable methods of water conservation and water demand management.

What is water end use analysis?
Water end use analysis involves breaking down water consumption in the home to individual end uses including showers, baths, toilets, taps, dishwashers and washing machines. End use analysis allows us to determine the exact amount of water used in various parts of the house. This, in turn, allows us to pinpoint areas of high water use and to focus on ways to reduce water consumption in such areas. There is very little long term end use data for typical residential properties across South East Queensland therefore it is an opportunity to be involved in important and unique research.

What is an internal house assessment and flow trace analysis?
An internal house assessment simply involves noting the water use devices within the home such as showers, toilets, washing machines, dishwashers and taps. This information will assist us in determining where water is used in the home. A flow trace analysis is carried out to determine the flow of water through water use devices in the home. Running the shower and flushing the toilet at a time recorded by a research member is an example of flow trace analysis.

What is a high resolution water meter and how does it work?
A high resolution meter is a water meter which can read low volumes of water flow. Currently water meters read every 5 litres of water that is supplied to your home, high resolution meters will be able to read every 0.014 litres of water. This enables us to accurately determine low end uses such as tap flow and leaks in the home.

What is a data logger and how does it work?
The data logger is attached to the household water meter. A data logger is a device that records and stores data, in this case water consumption data. The high resolution water meter and the data logger both sit within the meter box, minimising disturbance to the house owner.

What will happen if my water meter is affected during the installation and displays incorrect meter readings?
Your current water meter will be replaced with a brand new water meter. These water meters have a higher accuracy rate and therefore the chance of the meter displaying incorrect readings will be very unlikely. If you believe there is a problem with your replaced meter please contact the research team so we can investigate the issue immediately.

How can I find out more about the study?
If you would like to receive a summary of the findings of the study once it is concluded, please tick the appropriate box on the consent form attached. In addition, you may contact us at any time during the study for more information.

What is the best way to contact someone about the research?
Please feel free to contact Dr. Anneliese Spinks about any aspect of this project. Phone: 07 3214 2307; email: anneliese.spinks@csiro.au; postal address: CSIRO Sustainable Ecosystems, 306 Carmody Road, St Lucia, Qld, 4067.

This study has been cleared in accordance with the ethical review processes of the University of Queensland. If you have any questions concerning your participation in the study feel free to contact the researchers involved. If you would like to speak to an officer of the University not involved in the study, you may contact the University of Queensland Ethics Officer on 07 3365 3924.

Yours sincerely,

Dr Kelly Fielding
Senior Research Fellow
Institute for Social Science Research
The University of Queensland
Visiting Scientist , CSIRO Sustainable Ecosystems
306 Carmody Road
St Lucia, Qld, 4067
Tel: 07 3214 2419
Email: k.fielding@uq.edu.au
or kelly.fielding@csiro.au

Dr Rodney Stewart
Senior Lecturer
School of Engineering
Griffith University
Gold Coast Campus
Parklands Drive
Southport, Qld, 4215
Tel: 07 5552 8778
Email: r.stewart@griffith.edu.au

Dr Anneliese Spinks
Project Scientist
CSIRO Sustainable Ecosystems
306 Carmody Road
St Lucia, Qld, 4067
Tel: 07 3214 2307
Email: anneliese.spinks@csiro.au

Dr Aditi Mankad
Project Scientist
CSIRO Sustainable Ecosystems
306 Carmody Road
St Lucia, Qld, 4067
Tel: 07 3214 2331
Email: aditi.mankad@csiro.au

Dr Sally Russell
Lecturer
Griffith Business School
Nathan Campus
170 Kessels Road
Nathan, Qld, 4111
Tel: 07 3735 7577
Email: s.russell@griffith.edu.au

Dr Cara Beal
Research Fellow
Smart Water Centre
Griffith University
Gold Coast Campus
Parklands Drive
Tel: 07 5552 8156
Email: c.beal@griffith.edu.au

APPENDIX B. Consent Form

THE UNIVERSITY OF QUEENSLAND AUSTRALIA   CSIRO   Griffith UNIVERSITY

CONSENT FORM

Title of Research Project: Systematic Social Analysis of Residential Water Use

Your involvement in the Systematic Social Analysis of Residential Water Use is highly valued. Please review the information below and sign in the box on the reverse side of this page if you agree to participate in the study.

I acknowledge that:

- I agree to participate in the project.
- I will not be identified personally at any stage of the project and all data will be kept confidential and only seen by researchers involved in the research project.
- Questions in regards to my participation have been answered to my satisfaction.
- I can obtain further information from the research team at any time during the project.
- I understand that this study has been cleared in accordance with the ethical review processes of the University of Queensland. If I have any questions concerning my participation in the study I should feel free to contact the researchers involved. I understand that I can also speak to an officer of the University not involved in the study, by contacting the University of Queensland Ethics Officer on 07 3365 3924.
- I have been provided with the contact details of the investigating officers (see Information sheet).
- I understand that I can withdraw from this study at any time without penalty and without giving an explanation for my withdrawal.
- I understand that I may ask that part or all of my data be removed from the study without penalty or explanation. Data that is removed from the study will be deleted and will not be included in any of the further investigations.

By signing this form, I confirm that I have read and understood the information package and note that my involvement in this research will include participation in the following activities:

- **Completion of two household surveys during 2010**
- **Receiving advice and / or small appliances to assist the household with water conservation**

In addition, my participation in this research <u>may</u> include the replacement of my household water meter with a high resolution water meter.
If the water meter replacement does occur then:

- The replacement will take place between November 2009 and April, 2010 and will not involve any cost to my household.
- Once replaced the high resolution water meter will serve as my household water meter on an ongoing basis, allowing the council to read my water meter as they usually do.
- Researchers from the project will attach a data logger to my water meter and record the water use of the household from the time of installation to December 2011.
- I understand that if I have any complaints about the water meter replacement process I can contact Dr Rodney Stewart (Tel: 07 5582 8105, r.stewart@griffith.edu.au)
- I understand that individual data collected from the smart meter readings will be kept strictly confidential and for research purposes only.

I am the registered owner of the premise nominated below

Name		If you would like to be informed of the results please tick what information you would prefer: ☐ Summary of findings ☐ Copy of final publications Please provide your contact details below.
Signature		
Date		
Residential Address: **Postal Address (if different from residential):** **Email:** **Phone:**		

Please return this form <u>in the envelope provided</u> or mail to:

CSIRO Sustainable Ecosystems
Water Demand Survey
Reply Paid 84366
St Lucia, Qld, 4067

Or alternatively, you can fax the form to (07) 3214 2308 or scan and email it to: anneliese.spinks@csiro.au

APPENDIX C. Initial Letter to Intervention Participants

(Three Experimental Conditions)

Strategies to save water

Dear

Thank you for being part of the Strategies to Save Water study.

Your contribution to our research is very important and will help us understand how households in South East Queensland (SEQ) can save water around the home.

Even though damn levels in SEQ are currently high, it is still critical for households to continue being water efficient for the following reasons:

Delaying need for increased water infrastructure

By using less water, households in SEQ can help delay the need for new water infrastructure projects. It is expensive to build and develop new water supplies such as dams, desalination plants and water recycling plants. While we know that new supplies will be needed in the future, we can delay these supplies if everyone uses water efficiently in their homes.

Projected population growth in SEQ

The population in South East Queensland is projected to reach 4.4 million by 2031. As the population increases, the amount of water needed in the region will also increase and there will be a need for new water supplies. As we note before, using water efficiently around the home will delay the need for new water supplies.

Risk of future water shortages due to drought

The SEQ water supply is reliant upon sufficient rainfall in the region to feed catchment areas and dams. The recent drought that affected SEQ from 2003 until 2008 saw dam levels plummet to their lowest recorded levels. Although rainfall in subsequent years has been plentiful, prolonged drought conditions may occur again in the future.

Costs of water and water treatment

It requires a lot of energy to collect, treat and pump energy around the region and into homes. Energy is expensive to generate and its use has negative impacts on the environment. Therefore, by using less water, households in SEQ can not only save themselves money, but also help to protect the environment through using less energy.

Over the next five months we will be providing you with information about how your household can use water efficiently around the home. In approximately six months, we will send you another survey that will be similar (but shorter) to the one you have already completed for us.

If you have any questions about the research please feel free to contact Dr Anneliese Spinks (ph: 3214 2407; email: anneliese.spinks@csiro.au).

Yours sincerely,

Dr Anneliese Spinks - Dr Kelly Fielding - Dr Aditi Mankad - Dr Sally Russell - Dr Rodney Stewart - Dr Cara Beal

(Control Condition)

Strategies to
save
water

Dear

Thank you for being part of the Strategies to Save Water study.

Your contribution to our research is very important and will help us understand how households in South East Queensland (SEQ) can save water around the home.

Even though damn levels in SEQ are currently high, it is still critical for households to continue being water efficient for the following reasons:

Delaying need for increased water infrastructure

By using less water, households in SEQ can help delay the need for new water infrastructure projects. It is expensive to build and develop new water supplies such as dams, desalination plants and water recycling plants. While we know that new supplies will be needed in the future, we can delay these supplies if everyone uses water efficiently in their homes.

Projected population growth in SEQ

The population in South East Queensland is projected to reach 4.4 million by 2031. As the population increases, the amount of water needed in the region will also increase and there will be a need for new water supplies. As we note before, using water efficiently around the home will delay the need for new water supplies.

Risk of future water shortages due to drought

The SEQ water supply is reliant upon sufficient rainfall in the region to feed catchment areas and dams. The recent drought that affected SEQ from 2003 until 2008 saw dam levels plummet to their lowest recorded levels. Although rainfall in subsequent years has been plentiful, prolonged drought conditions may occur again in the future.

Costs of water and water treatment

It requires a lot of energy to collect, treat and pump energy around the region and into homes. Energy is expensive to generate and its use has negative impacts on the environment. Therefore, by using less water, households in SEQ can not only save themselves money, but also help to protect the environment through using less energy.

In approximately six months, we will send you another survey that will be similar (but shorter) to the one you have already completed for us.

If you have any questions about the research please feel free to contact Dr Anneliese Spinks (ph: 3214 2407; email: anneliese.spinks@csiro.au).

Yours sincerely,

Dr Anneliese Spinks - Dr Kelly Fielding - Dr Aditi Mankad - Dr Sally Russell - Dr Rodney Stewart - Dr Cara Beal

APPENDIX D. Intervention Postcards

Postcard 1 (Bathroom)

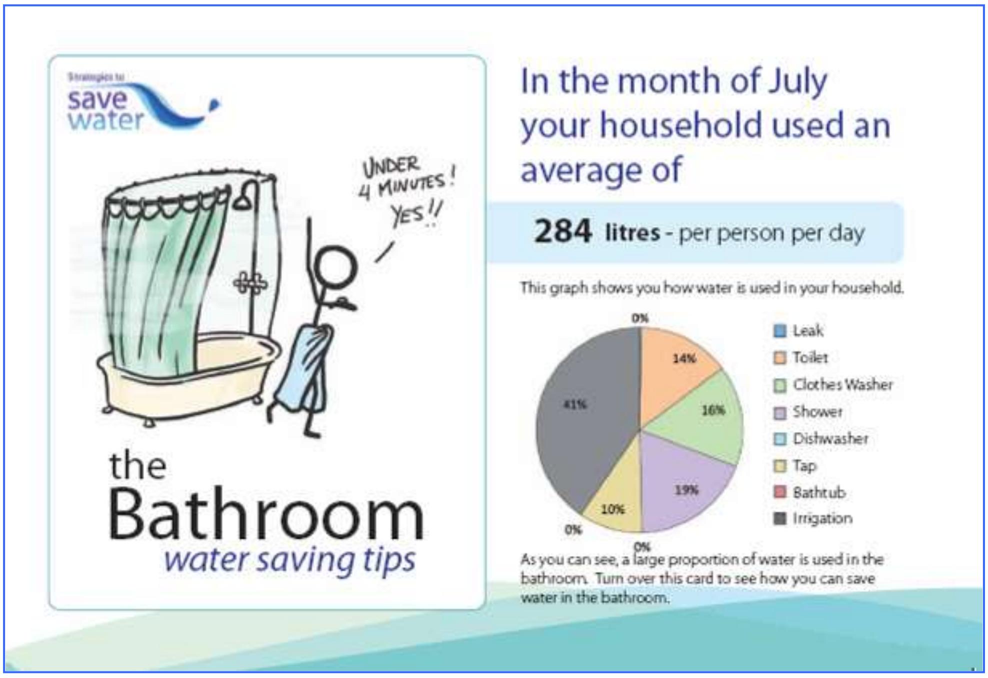
Side 1 (All Conditions)

Side 2 - Descriptive Norm Condition
Single Person Households

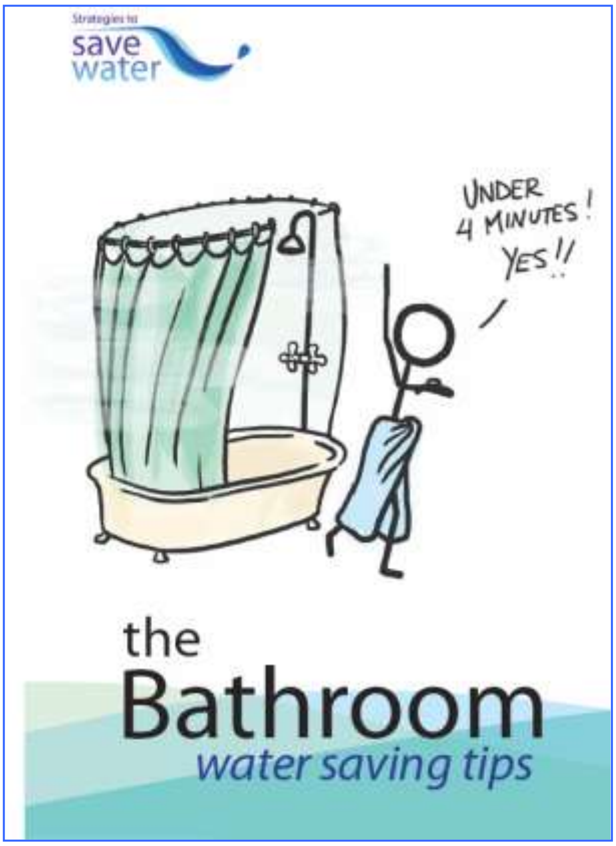
Family Households

Multiple Adult Households

Side 2 - Water End Use Condition (example)



Side 2 - Information Only Condition

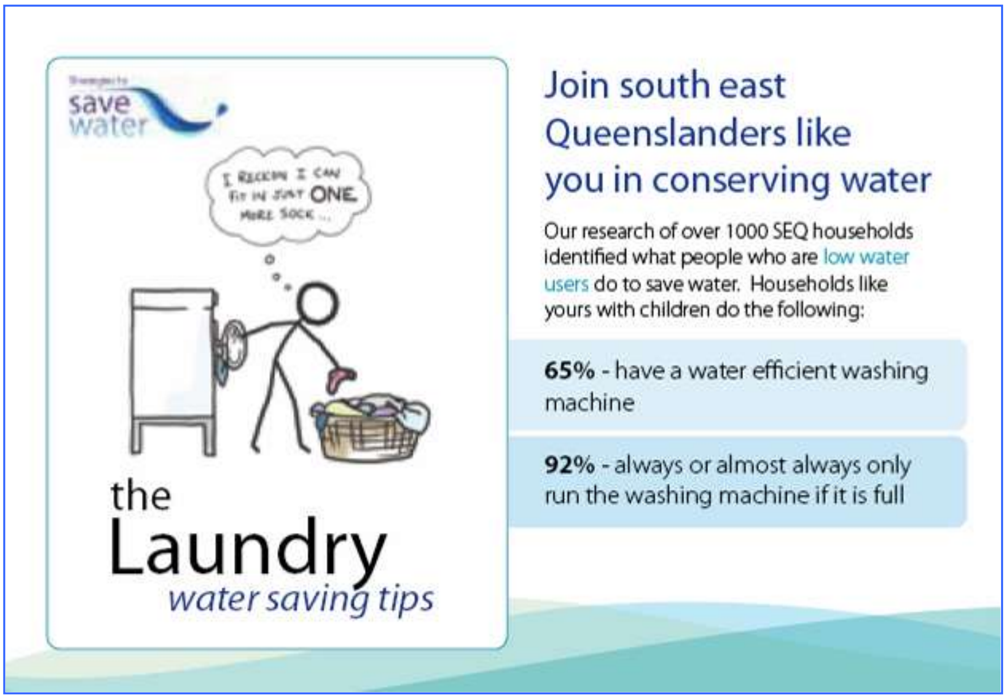


Postcard 2 (Laundry)

Side 1 (All Conditions)

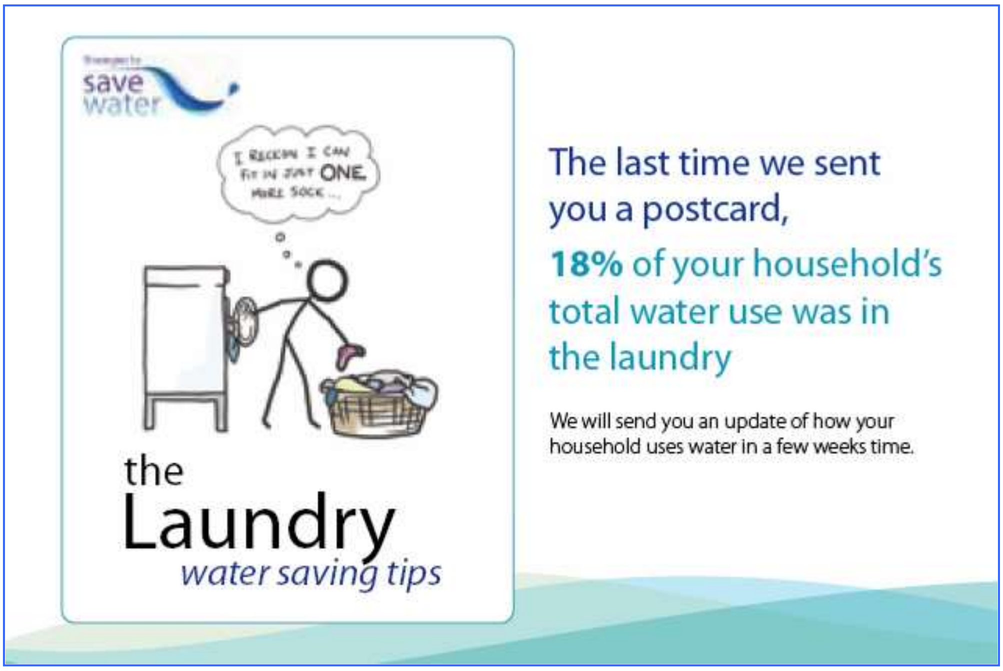
Side 2 - Descriptive Norm Condition
Single person households

Family Households



Multiple Adult Households

Side 2 - Water End Use Condition (example)



Side 2 - Information Only Condition

Postcard 3 (Kitchen)

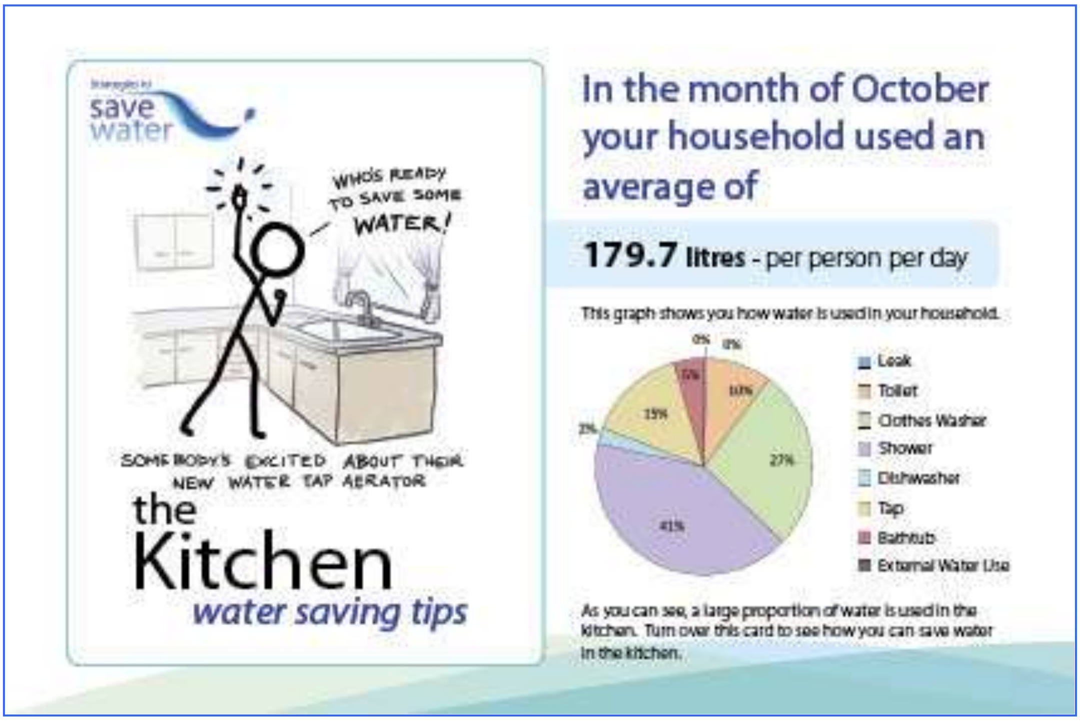
Side 1 (All conditions)

Side 2 - Descriptive Norm Condition
Single Person Households

Family Households

Multiple Adult Households

Side 2 - Water End Use Condition (example)



Side 2 - Information only Condition

Postcard 4 (Leaks)

Side 1 (All conditions)

Side 2 - Descriptive Norm Condition
Single person households

Family Households

Multiple Adult Households

Side 2 - Water End Use Condition
Leak detected

No Leak Detected

Side 2 - Information Only Condition

APPENDIX E. Pre-Survey Letter to Participants

Dear

Since the beginning of our research into household water use, the South East Queensland community has seen some dramatic changes in the availability of water. During this time, we experienced our dam levels rising from historic lows to over-flowing capacity, which ultimately ended in damaging floods throughout the region.

We have now reached the final stage of our research and we will soon be asking participants to complete a final short survey for us. In spite of everything that has occurred, we still value your responses and your input remains a vital component of our research. The information you give us will help us understand how people use water in their homes. Although it may seem very unlikely at the moment, the region may face significant water shortages again in the future. Therefore, understanding community views on water use during times of water shortage and water surplus are critically important for long-term water management.

During this project we have relied on the participation and cooperation of community members such as yourself throughout the region. Unfortunately, we do know that some of our participants have been adversely affected by the recent floods and have suffered significant property loss. We are also aware that many individuals and families who do not live in the flooded areas were also impacted either through having close family and friends who were affected, or through damage to businesses and other property.

Although, to the best of our knowledge, your home was not situated in one of the flooded areas, we understand that you may have been affected by the recent events. Therefore, if you would prefer not to participate in the final stage, please let us know by contacting us through one of the ways listed below. We hope, however, that you would still like to take part; we certainly value your contribution immensely.

Ways to contact someone about this research
Please feel free to contact Dr. Anneliese Spinks about any aspect of this project or if you have any concerns about being able to respond to the final survey.
Phone: 07 3833 5743; email: anneliese.spinks@csiro.au;
Postal address: CSIRO Ecosystem Sciences, 41 Boggo Rd, Dutton Park, Qld, 4102.

Yours sincerely,

Dr Kelly Fielding Dr Anneliese Spinks Dr Sally Russell Dr Rodney Stewart Dr Aditi Mankad Dr Cara Beal

APPENDIX F. Study Variables and Scale Construction

Table F1. Items assessing curtailment Theory of Planned Behaviour variables.

Variable	Variable Format	Variable Source
Directly measured variables (No. items)		
Attitudes (4)	7 point Likert Scale	Participant reported
Subjective Norms (3)	7 point Likert Scale	Participant reported
Moral Norms (3)	7 point Likert Scale	Participant reported
Descriptive Norm (1)	7 point Likert Scale	Participant reported
Perceived Behavioural Control (PBC) (3)	7 point Likert Scale	Participant reported
Past Behaviour (11)	5 point Likert Scale plus 'NA' option	Participant reported
Overall Intentions (3)	7 point Likert Scale	Participant reported
Specific Intentions (11)	5 point Likert Scale plus 'NA' option	Participant reported
Constructed variables		
Curtailment Attitudes	Scale	Constructed from Curtailment Attitude items
Curtailment Subjective Norms	Scale	Constructed from Curtailment Subjective Norm items
Curtailment Moral norms	Scale	Constructed from Curtailment Moral Norm items
Curtailment Overall Intentions	Scale	Constructed from Curtailment Overall Intention items

Table F2. Items assessing efficiency Theory of Planned Behaviour variables.

Variable	Variable Format	Variable Source
Directly measured variables (No. items)		
Attitudes (4)	7 point Likert Scale	Participant reported
Subjective Norms (3)	7 point Likert Scale	Participant reported
Moral Norms (3)	7 point Likert Scale	Participant reported
Descriptive Norm (1)	7 point Likert Scale	Participant reported
Perceived Behavioural Control (PBC) (3)	7 point Likert Scale	Participant reported
Past Behaviour (11)	5 point Likert Scale plus 'NA' and 'Already Installed' options	Participant reported
Overall Intentions (3)	7 point Likert Scale	Participant reported
Specific Intentions (11)	5 point Likert Scale plus 'NA' and 'Already Installed' options	Participant reported
Constructed variables		
Efficiency Attitudes	Scale	Constructed from Efficiency Attitude items
Efficiency Subjective Norms	Scale	Constructed from Efficiency Subjective Norm items
Efficiency Moral Norms	Scale	Constructed from Efficiency Moral Norm items
Past Behaviour Index	Scale	Constructed from Efficiency Past Behaviour items
Efficiency Overall Intentions	Scale	Constructed from Efficiency Overall Intention items

Table F3. Expanded Theory of Planned Behaviour variables.

Variable	Variable Format	Variable Source
Directly measured variables (No. items)		
Community Identification (3)	7 point Likert Scale	Participant reported
Self Identity (2)	7 point Likert Scale	Participant reported
Household Identity (8)	7 point Likert Scale	Participant reported
Constructed variables		
Community Identification Scale	Scale	Constructed from Community Identification items
Self Identity Scale	Scale	Constructed from Self Identity items
Household Culture	Scale	Constructed from Household Identity items

Table F4. Participant demographic and household variables.

Variable	Variable Format	Variable Source
Directly measured variables		
Year of birth	DD/MM/YYYY	Participant reported
Gender	1) male 2) female	Participant reported
Household income	1) < $30 000 2) $30 000-59 999 3) $60 000-89 999 4) $90 000-119 999 5) $120 000-149 999 6) > $150 000 7) prefer not to respond	Participant reported
Household occupants	1) adults 2) children	Participant reported
Education	1) primary school 2) high school 3) trade/TAFE 4) tertiary undergraduate 5) tertiary postgraduate	Participant reported
Cultural background	1) Aboriginal/Torres Strait Islander 2) Anglo-European 3) Asian/Sub-continental 4) Polynesian 5) Middle-Eastern 6) African 7) Other	Participant reported
Household water user type	1) High water user 2) Medium water user 3) Low water user 4) Don't know	Participant reported
Constructed variables		
Age	Years	Calculated from report of year of birth
Age Category	1) 15 – 24 years 2) 25 – 54 years 3) 54 – 64 years 4) 65 years and over	Calculated from report of year of birth
Household Size	Total number of occupants	Calculated from number of residents

Table F5. Scale construction for Expanded Theory of Planned Behaviour variables.

Scale Name	Included Questionnaire Item *	Reliability
Curtailment Attitudes	Question 1: Bad - Good Question 1: Harmful - Beneficial Question 1: Worthless - Valuable Question 1: Unpleasant - Pleasant	alpha .813 Variable computed
Curtailment subjective norms	Question 3A Question 3B Question 3C	alpha .632 Variable computed
Curtailment moral norms	Question 3D Question 3E Question 3F	alpha .859 scale computed
Curtailment general intentions	Question 2 Question 4 Question 8	Alpha .882 Variable computed
Efficiency Attitudes	Question 10: Bad - Good Question 10: Harmful - Beneficial Question 10: Worthless - Valuable Question 10: Unpleasant - Pleasant	Alpha = .866 Scale computed
Efficiency subjective norms	Question 12A Question 12B Question 12C	alpha = .759 scale computed
Efficiency moral norms	Question 12D Question 12E Question 12F	alpha = .888 scale computed
Efficiency general intentions	Question 11 Question 13 Question 15	alpha = .890 scale computed
Community identification	Question 18A Question 18B Question 18C	Alpha = .914 Scale computed
Self identity	Question 23A Question 23B	Correlation (r) = .789 Mean calculated
Household culture	Question 24A Question 24B Question 24C Question 24D Question 24E Question 24F Question 24G Question 24H	alpha = .955 scale computed

REFERENCES

Abrahamse, W., Steg, L., Vlek, C. and Rothengatter, T. (2005). A review of intervention studies aimed at household energy conservation. *Journal of Environmental Psychology, 25 (3),* 273-291.

Australian Bureau of Statistics. (2006). *Census of Population and Housing.*

Ajzen, I.(1991).The theory of planned behavior, *Organizational Behavior and Human Decision Processes*, *50*(2), 179-211.

Armitage, C.J. and Conner, M. (2001). Efficacy of the theory of planned behaviour: A meta-analytic review. *British Journal of Social Psychology, 40*, 471-499.

Bates, B., Kundzewicz, Z.W., Wu, S. and Palutikof, J. (2008).*Climate Change and Water: IPCC Technical Report VI,* IPCC Secretariat, Geneva.

Beal, C.D., Stewart, R.A. and Huang, T. (2010). *South East Queensland Residential End Use Study: Baseline Results – Winter 2010.* Urban Water Security Research Alliance Technical Report No. 31.

Cialdini, R.B., Reno, R.R. and Kallgren, C.A. (1990). A focus theory of normative conduct: Recycling the concept of norms to reduce littering in public places. *Journal of Personality and Social Psychology, 58(6),* 1015-1026.

Clark, W. A. and J. C. Finley (2007). Determinants of water conservation intention in Blagoevgrad, Bulgaria, *Society and Natural Resources*, *20*, 613-327.

Conner, M. and Armitage, C.J. (1998). Extending the theory of planned behaviour: A review and avenues for further research. *Journal of Applied Social Psychology, 28*(15), 1429-1464.

CSIRO, (2010). *Water overview*. Retrieved April 7, 2010 from http://www.csiro.au/org/WaterOverview.html.

Fielding, K.S., Louis, W.R., Warren, C., and Thompson, A. (2009). *Environmental sustainability in residential housing: Understanding attitudes and behaviour towards waste, water, and energy consumption and conservation among Australian households.* Melbourne, Victoria: Australian Housing and Urban Research institute.

Fielding, K.S., Russell, S. and Grace, R. (2010). *Residential Water Demand Management in South East Queensland: A Report on Water Conservation Beliefs.* Urban Water Security Research Alliance Technical Report No. 24.

Fielding, K., Spinks, A., Russell, S. and Mankad, A. (2012). *Water Demand Management Study: Baseline Survey of Household Water Use (Part B)*. Urban Water Security Research Alliance Technical Report No. 93.

Gardner, G. T. and P. C. Stern (1996). *Environmental problems and human behavior*, Allyn and Bacon, Boston.

Holland, R.W., Aarts, H. and Langendam, D. (2006). Breaking and creating habits on the working floor: A field-experiment on the power of implementation intentions. *Journal of Experimental Social Psychology, 42,* 776-783.

Kantola, S. J., Syme, G.J. and Campbell, N.A. (1982). The role of individual differences and external variables in a test of the sufficiency of Fishbein's model to explain behavioral intentions to conserve water, *Journal of Applied Social Psychology*, *12*(1), 70-83.

Lam, S.-P. (1999). Predicting intentions to conserve water from the theory of planned behavior, perceived moral obligation, and perceived water right, *Journal of Applied Social Psychology*, *29*(5), 1058-1071.

Lam, S.-P. (2006). Predicting intention to save water: Theory of planned behavior, response efficacy, vulnerability, and perceived efficiency of alternative solutions, *Journal of Applied Social Psychology*, *36*(11), 2803-2824.

Manstead, A.S.R. and Parker, D. (1995). Evaluating and extending the theory of planned behaviour. In W. Stroebe and M. Hewstone (Eds), *European Review of Social Psychology* (Vol. 6, pp. 69-96). Chichester: Wiley.

Nolan, J M., Schultz, P. W., Cialdini, R B., Goldstein, N J. and Griskevicius, V. (2008). Normative Social Influence is Underdetected. *Personality and Social Psychology Bulletin*, 34, 913–923.

Ouellette, J.A. and Wood, W. (1998). Habit and intention in everyday life: The multiple processes by which past behaviour predicts future behaviour. *Psychological Bulletin, 124,* 54-74.

Partridge, E. (2008). From ambivalence to activism: Young people's environmental views and actions. *Youth Studies Australia, 27*, 18-25.

Russell, S. and Fielding, K. (2010). Water demand management research: A psychological perspective. *Water Resources Research, 46,* W05302, doi:10.1029/2009WR008408.

Schultz, P. W. (2002). Knowledge, education, and household recycling: Examining the knowledge-deficit model of behavior change. In T. Dietz and P. Stern (Eds.), *New tools for environmental protection* (pp. 67-82). Washington DC: National Academy of Sciences.

Schultz, P. W., Khazian, A. and Zaleski, A. (2008). Using normative social influence to promote conservation among hotel guests. *Social Influence, 3,* 4-23.

Stryker, S. (1968). Identity salience and role performance: The importance of symbolic interaction theory for family research. *Journal of Marriage and the Family, 30*, 558-564.

Stryker, S. (1980). *Symbolic interactionism: A social structural version.* Palo Alto CA: Benjamin/Cummings.

Walton, A. and Hume, M. (2011). Creating positive habits in water conservation: The case of the Queensland Water commission and the Target 140 campaign. *International Journal of Nonprofit and Voluntary Sector Marketing, 16,* 215-224.

Zelezny, L.C., Chua, P-P. and Aldrich, C. (2000). Elaborating on gender differences in environmentalism. *Journal of Social Issues, 56(3),* 443-457.

McCalley, L. and Midden, J. (2002). Energy conservation through product-integrated feedback: The roles of goal setting and social orientation. *Journal of Economic Psychology, 23* 589-603.

Becker, L. (1978). Joint effect of feedback and goal setting on performance: A field study of residential energy conservation. *Journal of Applied Psychology, 63*(4), 428-433.

Urban Water Security Research Alliance

www.urbanwateralliance.org.au